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July 1994

US Army Corps
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Waterways Experiment
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Case Study: Leaking Groundwater Monitor Well Casing

by Charlie B. Whitten, Jerald D. Broughton

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Prepared for U.S. Army Environmental Center

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by Charlie B. Whitten, Jerald D. Broughton

U.S. Army Corps of Engineers
Waterways Experiment Station
3909 Halls Ferry Road
Vicksburg, MS 39180-6199

Final report

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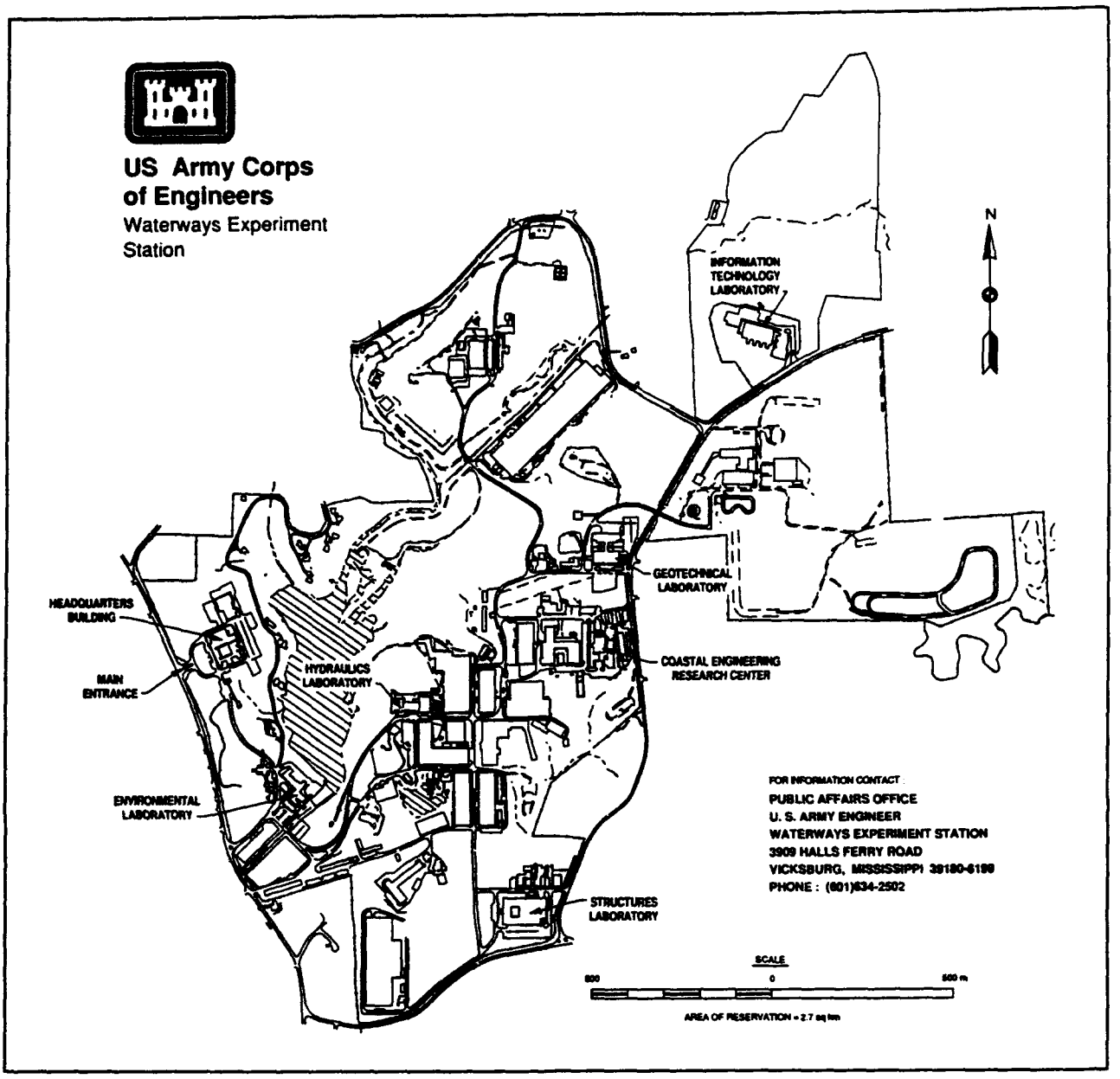
Prepared for U.S. Army Environmental Center
Aberdeen Proving Ground, MD 21010-5401



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Preface

A field sampling program was conducted by the Earthquake Engineering and Geosciences Division (EEGD), Geotechnical Laboratory (GL), U. S. Army Engineer Waterways Experiment Station (WES), during the period 14 February through 19 February 1993. The study was sponsored by the U. S. Army Environmental Center (AEC) under MIPR No. MIPR2273.

Field sampling were conducted by Mr. Charlie B. Whitten and Mr. Jerald D. Broughton of GL. Chemical analyses were by Analytical Laboratory Group (EE-A), Environmental Engineering Division (EE), Environmental Laboratory (EL). Analysis of the data and preparation of the report was accomplished by Mr. Charlie B. Whitten and Mr. Jerald D. Broughton. The work was performed under the direct supervision of Mr. J. L. Gatz, Chief, Engineering Geology Branch, EEGD, GL, and under the general supervision of Dr. A. G. Franklin, Chief, EEGD, GL, and Dr. W. F. Marcuson III, Director, GL.

At the time of publication of this report, Director of WES was Dr. R. W. Whalin. Commander was COL Bruce K. Howard, EN.

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Conversion Factors, Non-SI to SI Units of of Measurement

Non-SI units of measurement used in this report can be converted to SI units as follows.

Multiply	By	To Obtain
feet	0.3048	meters
inches	2.54	centimeters
miles (US statute)	1.609347	kilometers
pounds (mass)	0.4536	kilograms
gallons (US liquid)	3.785	cubic decimeters

1 Introduction

Monitor wells 4-8 and 4-9 at Umatilla Army Depot Activity (UMDA) are screened in a confined basalt interbed aquifer. The water table aquifer in the area is contaminated with explosives, and explosives have been detected in samples from wells 4-8 and 4-9. The contaminant concentrations in each well have varied several orders of magnitude over several sampling rounds. The samples were taken at the top of the water columns which are 150 and 180 feet above the well screen in wells 4-8 and 4-9, respectively. The variability of the contaminant concentrations at the top of the water column in both of the wells indicates the contaminants may be leaking through the well casings rather than coming from the confined basalt interbed aquifer.

Purpose

The purpose of the study was to determine if the explosive contaminants detected in wells 4-8 and 4-9 were in the confined basalt interbed aquifer in which the wells were screened, or if the contaminants were leaking through the well casings into the interbed aquifer. A field sampling program was conducted in February 1993 to determine the source of the explosive contaminants in wells 4-8 and 4-9.

Site Location and History

UMDA is located in northeastern Oregon, approximately 3 miles south of the Columbia River (Figure 1). The Depot occupies 19,728 acres in Umatilla and Morrow Counties. The Explosive Washout Lagoons consist of two adjacent lagoons located in the central portion of UMDA (Figure 2). Each of the rectangular shaped lagoons is about 25 feet wide, 70 feet long, and 6 feet deep. The unlined lagoons are constructed in native sands and gravels using the site soil for berms.

From the mid-1950's until 1965 the lagoons were used to collect, evaporate and infiltrate liquid wastes from the demilitarization of obsolete munitions at the Explosive Washout Plant located approximately 600 feet east of the lagoons. Environmental surveys performed at UMDA in 1981 (Dawson and

others, 1982) and 1986-87 (Century Environmental Sciences, 1986 and Century West Engineering Corporation, 1987) found explosives and explosive degradation products in the shallow groundwater of the alluvial aquifer. A remedial investigation (RI) in 1987-1988 (Weston 1989) showed low levels of explosives in the weathered and fractured top surface of the basalt bedrock which underlies the shallow alluvial aquifer. Four deep monitor wells were installed in 1990 (Dames and Moore, 1992) in what was thought to be the first basalt interbed aquifer beneath the alluvial aquifer. Contaminant levels similar to that found in the alluvial aquifer were detected in two of the basalt interbed aquifer monitor wells. Supplementary RI work at the site in 1992 (Dames and Moore, 1993) showed the four deep monitor wells were actually screened in the second, rather than the first, basalt interbed aquifer beneath the alluvial aquifer.

Site Description

Topography

The washout lagoons are located in a erosional feature called Coyote Coulee which was created by catastrophic flooding from the sudden release of water impounded in glacial Lake Missoula. Lake Missoula was formed in western Montana when the advance of glaciers temporarily blocked normal river drainage and large scale flooding resulted from the sudden release of the water when an ice dam failed. Surface features in the area of UMDA include large scale current ripples with wave lengths of hundreds of feet. The western side of the coulee slopes gently upward to the west-northwest while the eastern side is a steep bluff, 50 to 75 feet high at the washout lagoons. The lagoons are located at the base of the steep bluff.

Geology

UMDA is located on alluvium deposited by the Lake Missoula catastrophic flooding. The alluvium varies from clays to cobbles, but in the area of the washout lagoons it consists primarily of sands and gravels with some silts at the base. The alluvium is about 75 feet thick in the bottom of Coyote Coulee and 150 feet thick at the top of the steep bluff to the east.

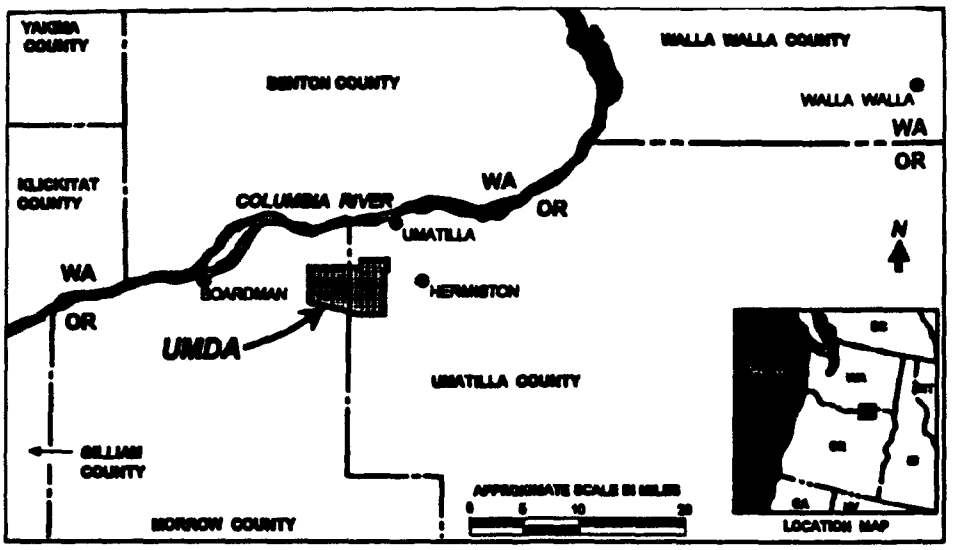

Figure 1. Site location

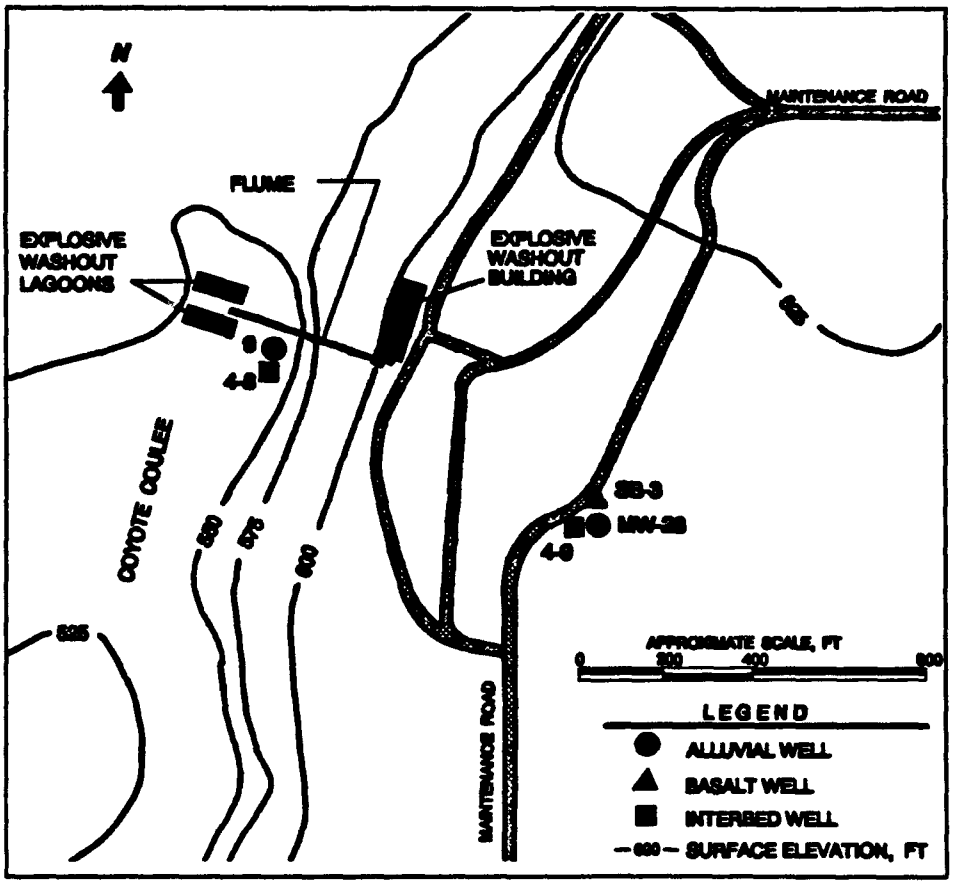

Figure 2. Location of monitor wells 4-8 and 4-9

Underlying the alluvium are several thousand feet of the Columbia River basalts. Drilling at the washout lagoon area encountered, in order from top to bottom, the Elephant Mountain (approximately 50 feet thick), Pomona (approximately 100 feet thick), and Umatilla members of the Columbia River basalts. Drilling for well 4-9 was stopped approximately 20 feet into the Umatilla basalt. Located between each of the basalt units is a 10-30 foot thick unit referred to as a flowtop or interbed. The interbed consists of weathered rock and/or sediments deposited on top of the underlying basalt prior to placement of the next basalt. The Rattlesnake Ridge Interbed is between the Elephant Mountain and Pomona basalts, and the Selah Interbed is between the Pomona and Umatilla basalts.

Groundwater

The alluvial aquifer is an unconfined aquifer that includes the lower 20 to 25 feet of the alluvium and the upper weathered, fractured surface of the Elephant Mountain basalt. The groundwater flow direction in the alluvial aquifer at the washout lagoons varies from northwest to southeast. Water level elevations in the area shown in figure 2 were between 495 and 500 feet in 1990-91, however the difference in water level elevations across the area at any time was less than one foot. The elongate shape of the contaminant plume southeast of the source area indicates the predominant flow direction is to the southeast (Figure 3). The variations in groundwater flow direction are caused by agricultural practices in the vicinity of UMDA. Groundwater is extracted for irrigation during the growing season and recharge canals, located south of UMDA, are used to recharge the alluvial aquifer during the winter and spring months. Groundwater flow direction would normally be to the north-northwest toward the Columbia River which is approximately 3 miles north of UMDA.

Water level data from the four wells screened in the Selah Interbed aquifer show groundwater flow in the Selah Interbed aquifer is to the north-northwest. Recorded water level elevations at well 4-9 in 1991 varied between 458.96 and 466.43 feet while elevations at well 4-8 varied between 441.13 and 446.06 feet. The recorded water level measurements show the water level in well 4-9 is usually 17 to 19 feet higher than the water level in well 4-8.

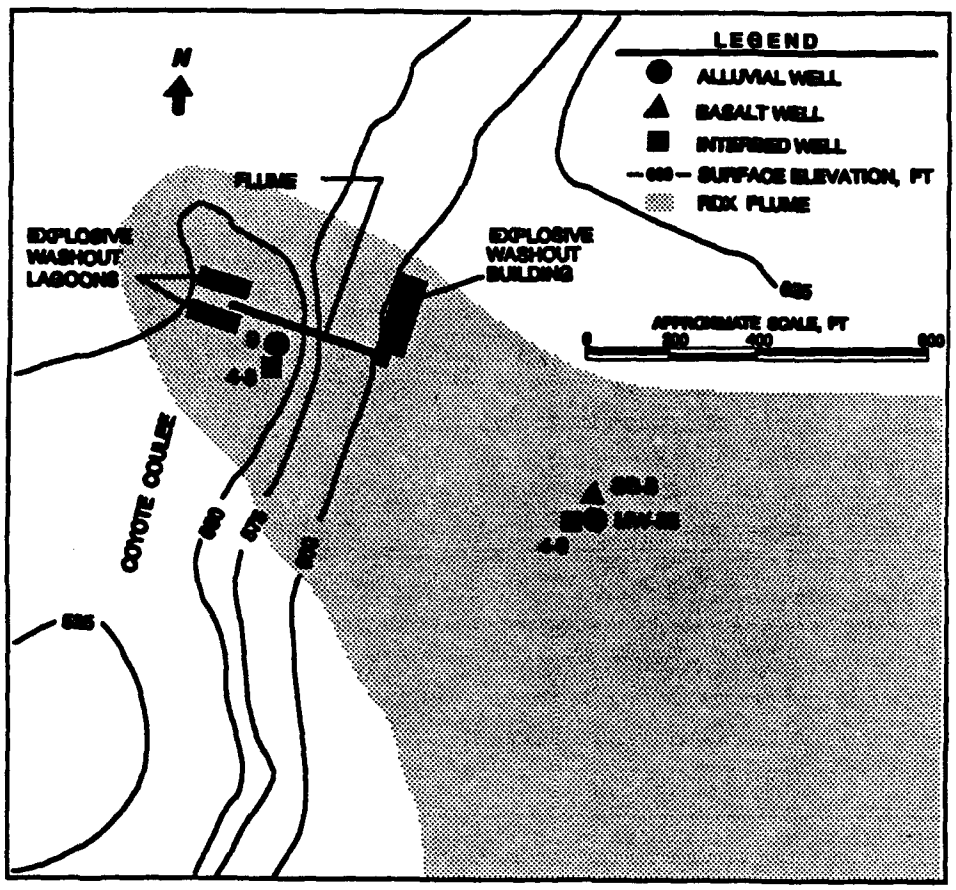

Figure 3. RDX plume in the alluvial aquifer in the area of wells 4-8 and 4-9. All the monitor wells used to define the RDX plume are not shown on this figure

2 Monitor Well Installation

Drilling

The bore hole for well 4-8 was started on August 7, 1990 and completed on August 9, 1990. The bore was drilled to refusal at 99.5 feet with a Becker System 10-3/4 inch triple wall casing. The outer casing of the triple wall casing was temporarily seated in the basalt bedrock to seal off the alluvial aquifer from the lower interbed aquifers. A 5-1/2 inch pilot hole was drilled from 99.5 feet to 285 feet with an air rotary drill rig. The 5-1/2 inch pilot hole was then reamed with a 7-7/8 inch bit to 285 feet with the air rotary rig. Figure 4 shows the monitor well completion details and geology of the location.

The bore hole for well 4-9 was started on August 7, 1990 and completed on August 14, 1990. The bore hole was drilled to refusal at 155 feet with a Becker System 10-3/4 inch triple wall casing. The outer casing of the triple wall casing was temporarily seated in the basalt bedrock to seal off the alluvial aquifer from the lower interbed aquifers. A 5-1/2 inch pilot hole was drilled from 155 feet to 360 feet with an air rotary drill rig. The 5-1/2 inch pilot hole was then reamed with a 7-7/8 inch bit to 340 feet with the air rotary rig. Figure 5 shows the monitor well completion details and geology of the location.

Well Construction

Well 4-8 was installed on August 10, 1990. Installation of the well began at 0710 hours and was completed at 2130 hours. The well screen was set from 271.5 to 281.5 feet below ground surface, with a threaded cap at the bottom (281.5 to 282 feet). The well screen is a 0.020 inch slotted 4-inch inside diameter (ID) polyvinyl chloride (PVC) screen. The well casing is threaded 4-inch I.D. schedule (SCH) 40 PVC pipe. The threaded cap at the bottom of the well screen was placed approximately 3 feet above the bottom of the 7-7/8 inch diameter bore hole. Table 1 lists the materials used to install the well and the depth from ground surface at which the materials were placed.

Well 4-9 was installed on August 15, 1990. The well screen was set from 326 to 336 feet below ground surface, with a threaded cap at the bottom. The well screen is a 0.020-inch slotted 4 inch ID PVC screen. The well casing is threaded 4 inch ID SCH 40 PVC pipe. The threaded cap at the bottom of the well screen was placed 4 feet above the bottom of the 7-7/8 inch diameter bore hole. Table 1 lists the materials used to install the well and the depth from ground surface at which the materials were placed.

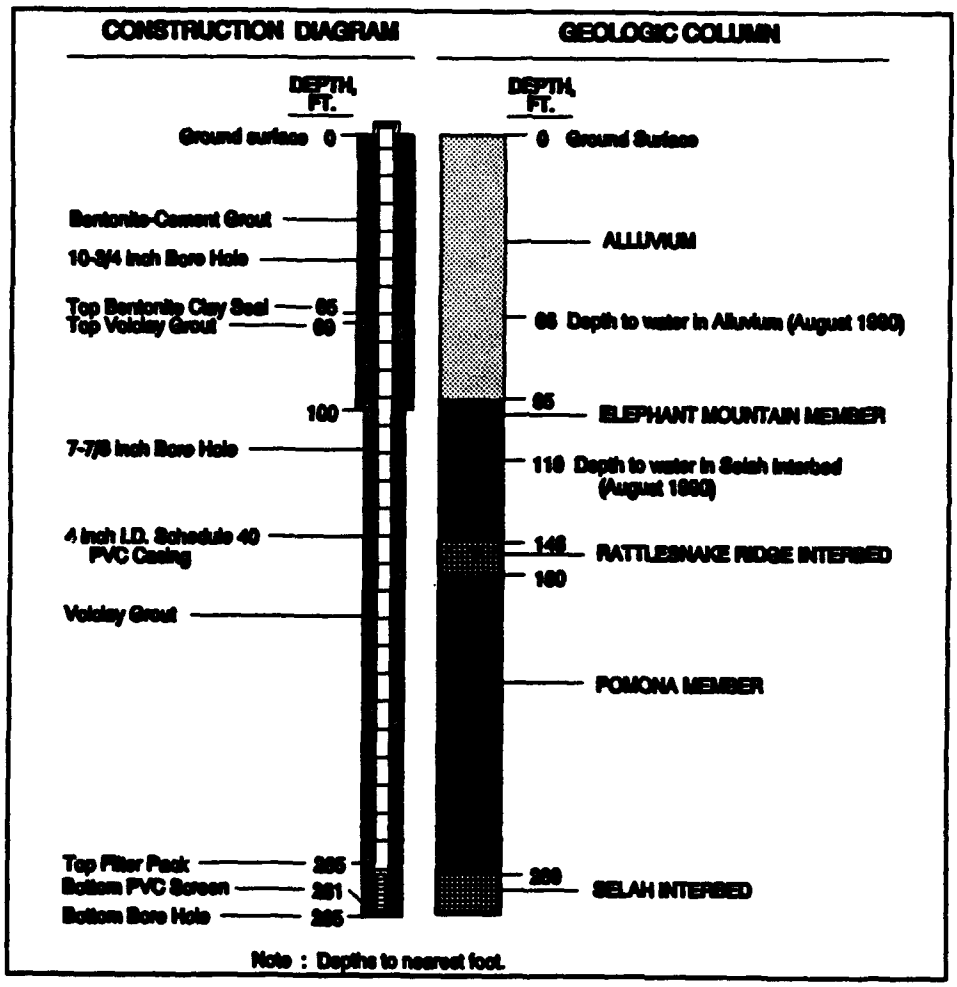

Figure 4. Well 4-8 construction diagram and geologic column

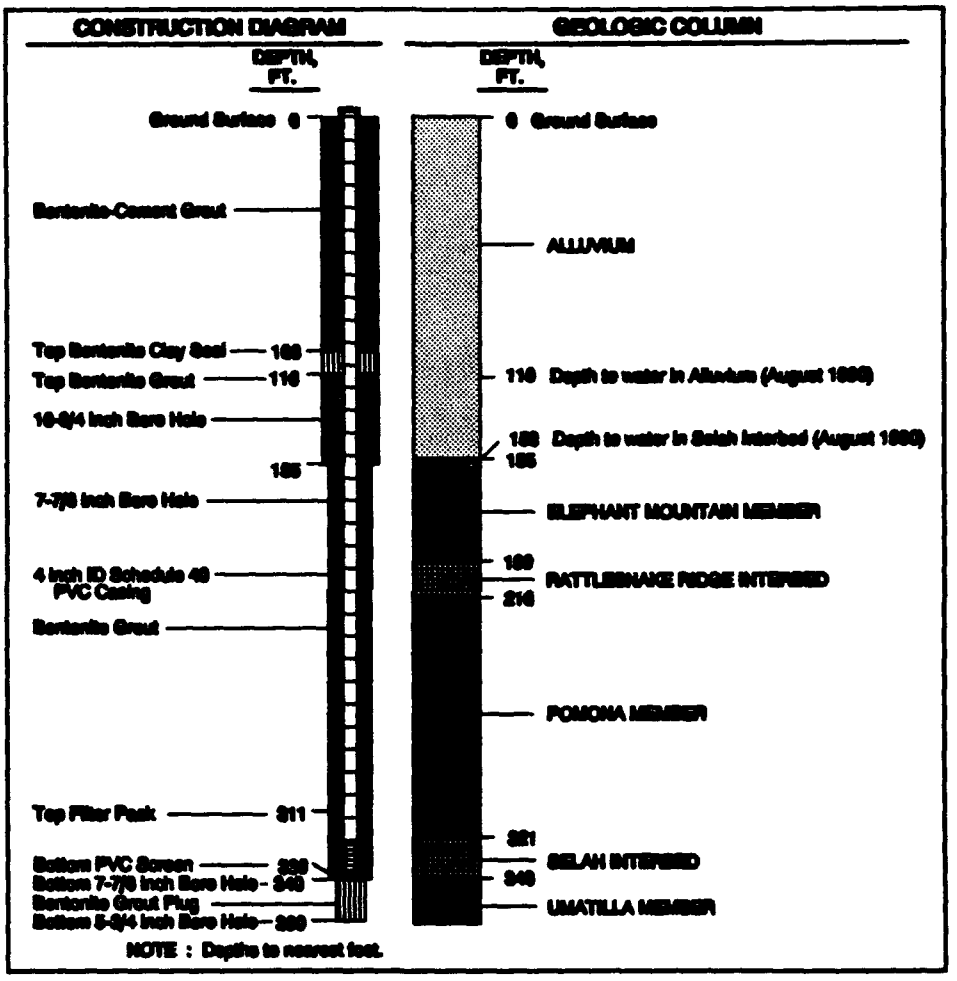

Figure 5. Well 4-9 construction diagram and geologic column

Table 1
Well 4-8 and 4-9 Construction Materials

Well	Depth, ft	Material	Quantity of Materials Used
4-8	0 to 65	grout mixture	twenty 94 pound bags of cement mixed with two 50 pound bags of bentonite powder
	65 to 69	bentonite pellet cap	ten 5 gallon buckets of 1/4-inch bentonite pellets
	69 to 265	volclay grout	twenty-two 50 pound bags of Volclay bentonite powder
	265 to 268	fine sand cap	one 100 pound bag of #10-20 sand
	268 to 285	filter pack	four and half 100 pound bags of #8-12 filter sand
	50 to 250	centralizers	one centralizer (5 total) every 50 feet
	0 to 271.5	4-in ID SCH 40 PVC casing	271.5 ft (plus 2.3 ft stick-up); 10 ft sections
	271.5 to 281.5	0.02-in slotted 4-in ID PVC screen	one 10 ft section
4-9	0 to 106	grout mixture	thirty-three 94 pound bags of cement mixed with two 50 pound bags of bentonite powder
	106 to 116	bentonite pellet cap	ten 5 gallon buckets of 1/4-inch bentonite pellets
	116 to 310.5	bentonite grout	twenty 50 pound bags of bentonite powder
	310.5 to 318	fine sand cap	two 100 pound bag of #10-20 sand
	318 to 340	filter pack	six 100 pound bags of #8-12 filter sand
	340 to 360	bentonite plug	two 50 pound bags bentonite powder
	50 to 300	centralizers	one centralizer (6 total) every 50 feet
	0 to 326	4-in ID SCH 40 PVC casing	326 ft (plus 2.1 ft stick-up); 10 ft sections
	326 to 336	0.02-in slotted 4-in ID PVC screen	one 10 ft section

3 Historical Chemical Data

During a regularly scheduled sampling round, sampling personnel noted that the initial purge water from well 4-8 had a yellowish color that cleared up before one well casing volume was removed from the well. The purge pump was placed at the top of the water column to purge the well. Samples for chemical analysis were also taken at the top of the water column with a bailer within 24 hours after the well had been purged. Contaminant concentrations from 4 sample rounds varied up to 2 orders of magnitude. During the December 1992 sampling round, well 4-8 was sampled immediately after the well was purged on December 16th and resampled on December 17th without purging. Both samples were taken at the top of the water column. The contaminant levels for the December 17th sample were 1 to 2 orders of magnitude higher than the December 16th sample.

The historical explosive chemical data used in this report were retrieved from the Installation Restoration Data Management Information System (IRDMIS) at the Army Environmental Center (AEC). The explosive analytes are:

- HMX — High Melting Explosive (cyclotetramethylenetetranitramine)
- RDX — Royal Demolition Explosive (hexahydro-1,3,5-trinitro-1,3,5-triazine)
- 1,3,5-TNB — 1,3,5-Trinitrobenzene
- 1,3-DNB — 1,3-Dinitrobenzene
- 2,4,6-TNT — 2,4,6-Trinitrotoluene
- 2,4-DNT — 2,4-Dinitrotoluene
- 2,6-DNT — 2,6-Dinitrotoluene
- NB — Nitrobenzene
- Tetryl

Appendix A is a print out of the chemical data from IRDMIS for monitor wells 9, MW-28, SB-3, 4-8 and 4-9.

Well Cluster 4-8

Wells 9 and 4-8 are approximately 25 feet apart and are located approximately 200 feet east-southeast of the washout lagoons. Well 9, installed in 1980, has a 15 foot screen at the top of the unconfined alluvial aquifer. Well 4-8, installed in 1990, has a 10 foot screen in the Selah Interbed, the second confined basalt interbed aquifer below the alluvial aquifer. Table 2 presents completion data for the monitoring wells used in this study.

Table 3 contains the historical explosive chemical data for wells 9 and 4-8. All nine of the analytes, except for tetryl and 2,6-DNT in well 4-8, listed above have been detected in both wells. The samples obtained in October-November 1990, February 1991, and 2-15 December 1992 are the only ones from both wells in the same sample round. The concentration of each analyte detected in both wells is generally 1 to 2 orders of magnitude higher in well 9 than in well 4-8, ie; RDX at 2,800 ug/L and 44.80 ug/L in wells 9 and 4-8, respectively, in October-November 1990. The concentration of an analyte in well 9 has generally varied less than one order of magnitude between sampling rounds. The concentration of an analyte in well 4-8 generally varies from 1 to 2 orders of magnitude between sampling rounds. For example, RDX varied from 2,300 ug/L to 3,600 ug/L in 3 sampling rounds in well 9 while varying from 5.03 ug/L to 3,300 ug/L in well 4-8 in 6 sampling rounds.

Well 4-8 was sampled the 2nd, 16th and 17th of December 1992. The sampling round on 2nd of December was a scheduled sampling round to sample all the groundwater monitor wells at the Washout Lagoons Area. The samplers noted that the purge water in well 4-8 was a yellowish color until the first well volume was removed, then the water cleared-up. The well was sampled on the 2nd of December, the day after it was purged. The samples on the 16th and 17th of December were taken to see if the color change was an indication of a change in chemical concentrations of the explosives. Well 4-8 was purged and immediately sampled on the 16th of December. The well was sampled without purging on the 17th of December. Both samples were taken at the top of the water column with a bailer. All of the explosives detected (HMX, RDX, 1,3,5-TNB, 2,4-DNT and 2,4,6-TNT) were 1 to 2 orders of magnitude higher on the 17th than on the 16th, with the exception of NB which was detected only in the sample taken the 16th. The analyte concentrations for the samples on the 2nd and 17th of December were the same order of magnitude.

Table 2
Well Screen Intervals

Well No.	Ground Surface Elevation, ft	Screened Interval Elevation, ft	Geologic Unit	Comments
9	569.3	486.8 to 501.8	Alluvium	Screened in top alluvial aquifer; unconfined water table aquifer
4-8	562.9	281.4 to 291.4	Selah Interbed	Screened in basalt flow top; confined aquifer; second flow top below alluvial aquifer
MW-28	614.3	478.8 to 498.8	Alluvium	Screened in top alluvial aquifer; unconfined water table aquifer
SB-3	614.2	431.2 to 441.2	Elephant Mountain Member basalt	Screened 21 feet below top of basalt-alluvium contact
4-9	614.0	278 to 288	Selah Interbed	Screened in basalt flow top; confined aquifer; second flow top below alluvial aquifer

Table 3
Historical Explosive Chemical Data for Wells 9 and 4-8

Analyte	Well No.	Date Sampled					
		Oct-Nov 1990	Feb 1991	Oct 1992	2-15 Dec 1992	16 Dec 1992	17 Dec 1992
HMX	9	590	1,300	n/s	1,300	n/s	n/s
	4-8	10.80	350	1,500	280	25.80	120
NB	9	15.70	<	n/s	<	n/s	n/s
	4-8	<	<	<	<	2.33	<
RDX	9	2,800	3,600	n/s	2,300	n/s	n/s
	4-8	44.80	650	3,300	420	5.03	170
TETRYL	9	<	<	n/s	8.53	n/s	n/s
	4-8	<	<	<	<	<	<
1,3-DNB	9	17.90	8.82	n/s	4.67	n/s	n/s
	4-8	<	0.85	<	<	<	<
1,3,5-TNB	9	420	440	n/s	260	n/s	n/s
	4-8	<	39.20	260	29.60	1.10	18.00
2,4-DNT	9	340	430	n/s	320	n/s	n/s
	4-8	1.48	60.00	280	41.00	3.67	22.30
2,4,6-TNT	9	3,100	3,200	n/s	2,900	n/s	n/s
	4-8	0.83	390	1,900	350	8.95	190
2,6-DNT	9	<	<	n/s	7.76	n/s	n/s
	4-8	<	<	<	<	<	<

n/s - not sampled Data in ug/L < - below detection limit

Well Cluster 4-9

Well 4-9 is clustered with wells MW-28 and SB-3. The well cluster is approximately 900 feet southeast of the washout lagoons. Well MW-28, installed in 1987, has a 20 foot screen at the top of the unconfined alluvial aquifer (Table 3). Well SB-3, installed in 1987, has a 10 foot screen with the top of the screen being 21 feet below the top of the Elephant Mountain basalt. The SB-3 well screen is in the weathered/fractured Elephant Mountain basalt. Well 4-9, installed in 1990, has a 10 foot screen in the Selah Interbed which is the second confined basalt interbed aquifer below the alluvial aquifer. Wells MW-28, SB-3 and 4-9 are about 20 feet apart.

Table 4 contains the historical explosive chemical data for wells MW-28, SB-3 and 4-9. NB and tetryl have not been detected in the wells. RDX is the only explosive that has been consistently detected in all three wells. HMX and 1,3,5-TNB have been detected consistently in wells MW-28 and 4-9 but not in well SB-3 where only 1,3,5-TNB was detected in 1 round. 1,3-DNB was detected in 3 of 4 sampling rounds in well MW-28, 1 of 4 rounds in well 4-9 and none of 4 rounds in well SB-3. 2,4,6-TNT was detected in 3 of 4 sample rounds in well 4-9, and not detected in 4 rounds in wells MW-28 and SB-3. 2,6-DNT was detected in only 1 of 4 sample rounds in MW-28, and not detected in 4 rounds in wells 4-9 and SB-3.

The concentrations of 1,3-DNB, 1,3,5-TNB, 2,4-DNT, 2,6-DNT and 2,4,6-TNT have not exceeded 5 ug/L. The concentrations of HMX are usually 1 order of magnitude higher in well MW-28 than in well 4-9, and has not been detected in well SB-3. The concentrations of RDX are similar in wells MW-28 (1,000 to 6,800 ug/L) and 4-9 (270 to 5,600 ug/L), but usually two to three orders of magnitude less in well SB-3 (0.65 to 8.26 ug/L).

Table 4
Historical Explosive Chemical Data for Wells MW-28, SB3 and 4-9

Analyte	Well	Date Sampled				
		June 1988	October-November 1990	February-March 1991	October 1992	December 1992
HMX	MW-28	<	15.60	20.10	n/s	60.00
	SB-3	<	<	<	n/s	<
	4-9	---	1.86	8.30	26.00	1.54
NB	MW-28	<	<	<	n/s	<
	SB-3	<	<	<	n/s	<
	4-9	---	<	<	<	<
RDX	MW-28	1,000	5,000	6,800	n/s	3,200
	SB-3	0.65	8.26	5.32	n/s	4.03
	4-9	---	1,100	5,600	4,400	270
TETRYL	MW-28	<	<	<	n/s	<
	SB-3	<	<	<	n/s	<
	4-9	---	<	<	<	<
1,3-DNB	MW-28	<	1.57	0.64	n/s	1.03
	SB-3	<	<	<	n/s	<
	4-9	---	<	1.01	<	<
1,3,5-TNB	MW-28	<	2.40	3.38	n/s	4.44
	SB-3	<	<	<	n/s	0.46
	4-9	---	<	0.78	2.75	0.69
2,4-DNT	MW-28	<	<	<	n/s	0.23
	SB-3	<	<	<	n/s	<
	4-9	---	<	<	0.73	0.31
2,4,6-TNT	MW-28	<	<	<	n/s	<
	SB-3	<	<	<	n/s	<
	4-9	---	1.67	<	4.43	4.02
2,6-DNT	MW-28	<	<	<	n/s	0.11
	SB-3	<	<	<	n/s	<
	4-9	---	<	<	<	<

--- - pre-well installation
n/s - not sampled
< - Below detection limit
Chemical data in ug/L

4 Data Collection and Analysis

Wells 4-8 and 4-9 were sampled in February 1993 to determine if the contaminants previously detected were leaking into the wells from the alluvial aquifer. The February 1993 samples were analyzed for the 9 analytes that had been reported in the IRDMIS data plus 2 additional analytes, 2A-DNT (2-Amino-4,6-Dintrotoluene) and 4A-DNT (4-Amino-2,6-Dintrotoluene).

Sampling Method

Three rounds of samples were taken at wells 4-8 and 4-9. The sampling schedules for each well were:

Pre-purge Bailer Sample	Prior to the well being purged with a submersible pump, a sample was taken at the top, middle and bottom of the water column with a point source bailer.
Purge Sample	As the well was purged with a submersible pump, a sample was taken at 0, 0.25, 0.5, 0.75 and 1 well volume, and at each well volume thereafter. The pump was placed at the top of the water column.
Post-purge Bailer Sample	One day after the well was purged with a submersible pump, a sample was taken at the top, middle and bottom of the water column with a point source bailer.

The point source bailer has a valve at each end of the bailer. Both valves are open as the bailer is lowered through the water column, allowing water to flow through the bailer. When the bailer is retrieved both valves close, capturing the water at the depth the bailer was stopped.

A Kech 2-inch submersible pump was used to purge each well. The pump was placed 3 to 5 feet below the top of the water column and pumped at a rate of 3 to 4 gallons per minute (gpm). Samples for chemical analysis were taken from the discharge line.

The point source bailer was triple rinsed with distilled water before each well was sampled. A sample of the last rinse water before the first sample was collected in each well was collected and analyzed. No explosives were detected in the samples.

The submersible pump was triple rinsed with distilled water before being used in each of the wells. A sample of the last rinse water from the initial rinseate was collected and analyzed. No explosives were detected.

Well 4-8

Pre-purge point source bailer samples were taken from 1310 to 1330 hours on 17 February 1993 (Table 5). The well was purged and sampled with a submersible pump from 1400 to 1540 hours on 17 February 1993. Post-purge point source bailer samples were taken from 0800 to 0830 hours on 18 February 1993. Point source bailer samples were taken at depths of 122 feet (top of water column), 202 feet (middle of water column) and 280 feet (bottom of water column). The bottom point source bailer samples were taken in the well screen. The chemical data are listed in Appendix B and discussed below.

Pre-purge bailer samples

Nine of the eleven explosive analytes were detected in the pre-purge bailer samples (Table 6). NB and 2,6-DNT were not detected. The concentration of each of the nine analytes detected generally decreased from the top to bottom samples, except for 2,4,6-TNT. The decreases in the concentrations were usually less than an order of magnitude. HMX and RDX concentrations decreased from 1320 ug/L to 937 ug/L, and 1930 ug/L to 1570 ug/L, respectively, from the top sample to the bottom sample, while decreases in the concentration of 1,3,5-TNB, 1,3-DNB, tetryl, 2,4-DNT, 2A-DNT and 4A-DNT were less than 24 ug/L from the top sample to the bottom sample. The highest concentration of 2,4,6-TNT was in the middle sample (1,810 ug/L) while the lowest was in the top sample (1,540 ug/L). Figures 6 and 7 show the relationships between analyte concentrations and depths sampled.

Table 5
Wells 4-8 and 4-9 Bailer Sample Times and Depths

Well Number	Date February 1993	Sample No.	Sample Time	Sample Depth from Top of PVC Casing, ft	Interval of Water Column Sampled	Depth to Bottom Screen, ft
4-9	16	156 - B	1100	156.1*	Top	336
		241 - B	1115	241	Middle	
		330 - B	1130	330	Bottom	
	18	156 - A	0700	156.1*	Top	
		241 - A	0715	241	Middle	
		330 - A	0730	330	Bottom	
4-8	17	122 - B	1310	122.2*	Top	281.5
		202 - B	1320	202	Middle	
		280 - B	1330	280	Bottom	
	18	122 - A	0800	122.2*	Top	
		202 -A	0815	202	Middle	
		280 - A	0830	280	Bottom	

Sample Time in military time

B -- sampled before purging

A -- sampled after purging

* --- depth to water table from top of PVC casing

Table 6
Well 4-8 Explosives Data for Bailer and Purge Samples

Sample	Analytes, ug/L								
	HMX	RDX	1,3,5-TNB	1,3-DNB	Tetryl	2,4,6-TNT	2,4-DNT	2A-DNT	4A-DNT
122 - B	1,320	1,930	155	1	6	1,540	164	32.2	26.6
202 - B	1,040	1,780	146	1	5.4	1,810	156	29.3	22.3
280 - B	937	1,570	131	0.8	5	1,650	141	28	21.3
0 -VP	1,040	1,900	146	1	4.8	1,440	159	28.4	21.4
0.25 -VP	1,000	1,620	131	0.9	5.6	1,680	144	29.9	22
0.50 -VP	924	1,550	128	0.9	4.8	1,570	136	28.4	21.4
0.75 -VP	870	1,440	119	0.9	5	1,480	130	28.8	21.4
1 -VP	829	1,440	110	0.9	5.4	1,390	124	30.7	22.5
2 -VP	47.7	50.3	3	<	1.5	41.6	6.5	12.4	8.4
3 -VP	26.5	18	1.3	<	0.9	15.9	4	10.6	6.3
4 -VP	24.9	16.2	1.3	<	<	15.1	3.6	10.3	6
5 -VP	19.6	1	1.2	<	0.8	10.3	3	9.2	4.9
122 - A	108	165	13	0.1 J	1.3	174	16.2	10.1	5.8
202 - A	30.8	305	2.6	<	<	32.2	4.7	9.2	4.9
280 - A	49.2	61	5	<	<	63	7.4	9.6	5.2

B -- Point source bailer samples taken 17 February 1993 before purging

VP -- Volume purged before sampling on 17 February 1993

A -- Point source bailer samples taken 18 February 1993 after purging

< -- Below Detection limit of 0.1 ug/L

J -- Estimated value

2,6-DNT and NB below detection limit in all samples

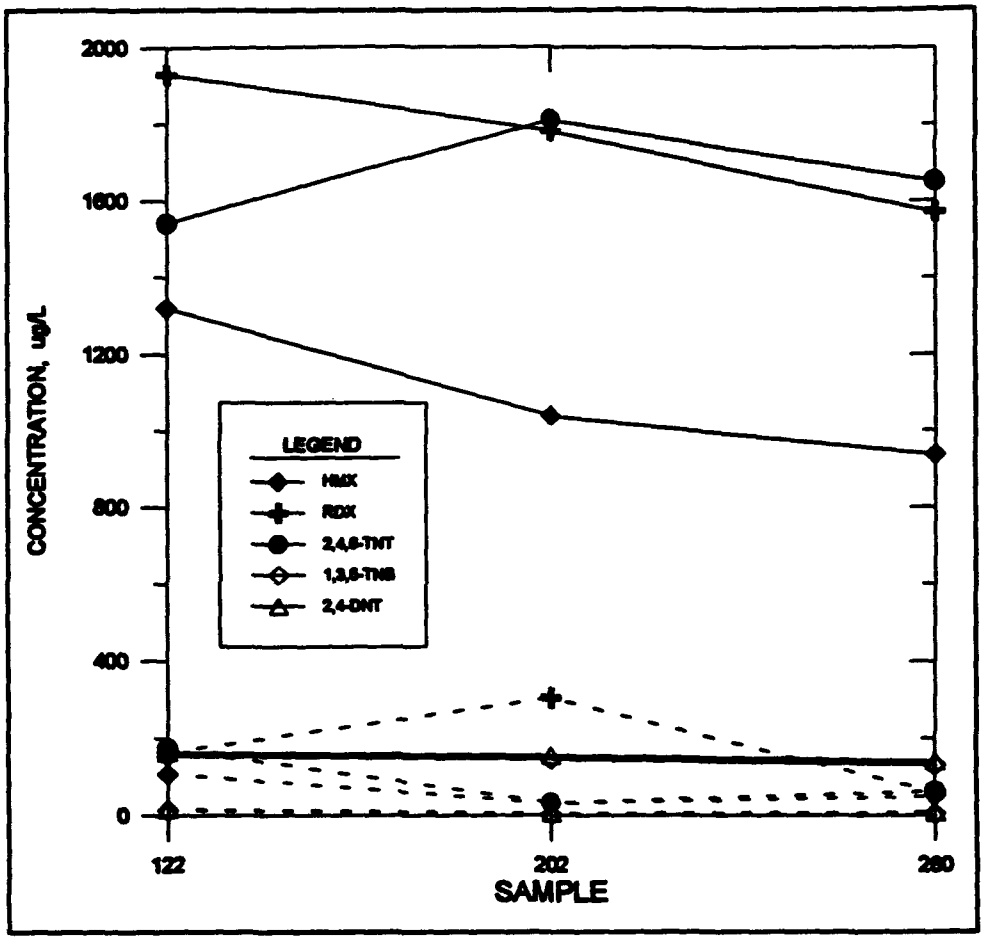

Figure 6. Concentration of HMX, RDX, 1,3,5-TNB, 2,4,6-TNT and 2,4-DNT in well 4-8 pre- (solid line) and post-purge (dash line) bailer samples

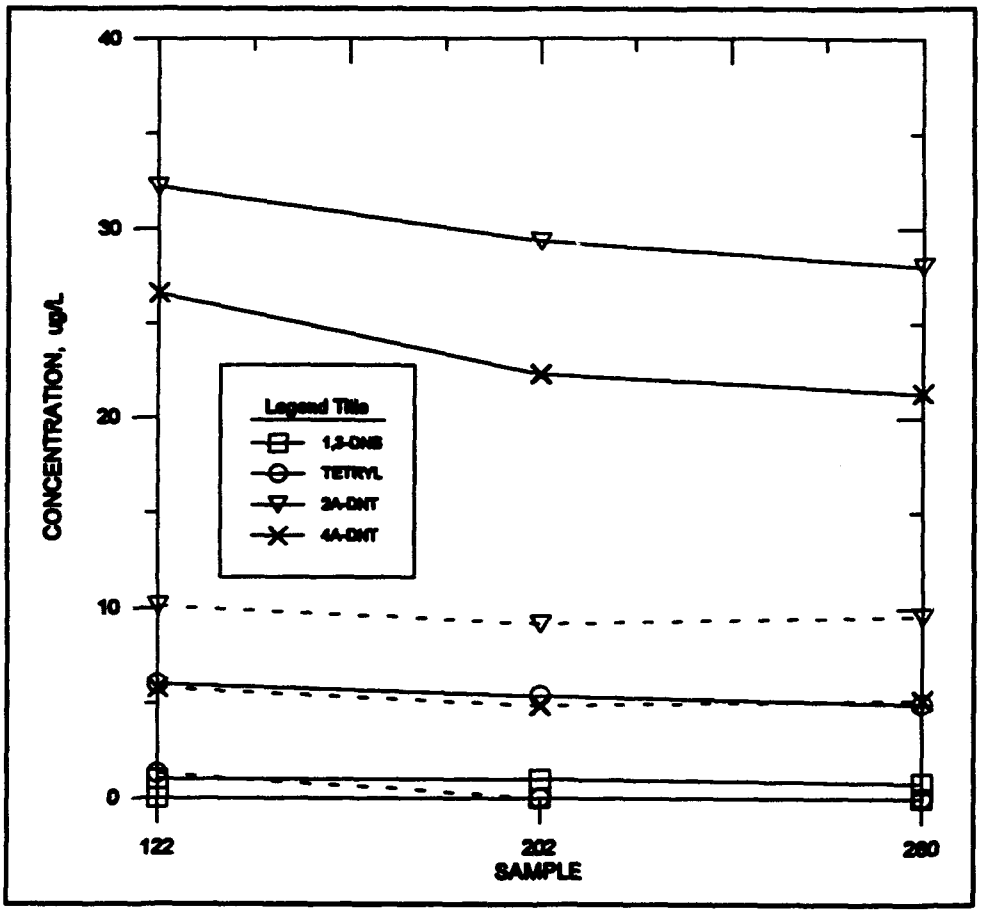

Figure 7. Concentration of 1,3-DNB, tetryl, 2A-DNT and 4A-DNT in well 4-8 pre- (solid line) and post-purge (dashed line) bailer samples

Purge samples

Five well casing volumes were removed from well 4-8 with a submersible pump positioned approximately 5 feet below the top of the water column. After approximately 5 gallons of water had been removed from the well the initial or 0 volume sample was taken. Samples were then taken when 0.25, 0.50, 0.75, 1, 2, 3, 4 and 5 well casing volumes were removed. The same nine explosive analytes detected in the pre-purge bailer samples were detected in the purge samples (Table 6).

The explosives data from O thru 1 well volumes are similar to the pre-purge bailer data. For example HMX concentrations for the pre-purge bailer samples were 1,320 ug/L, 1,040 ug/L and 937 ug/L for the top, middle and bottom samples, respectively, while the corresponding purge volume samples were 1,040 ug/L, 924 ug/L and 829 ug/L for the 0, 0.50 and 1 volume samples, respectively. HMX, RDX, 1,3,5-TNB, and 2,4-DNT show a general decline in concentration, usually not exceeding 1 order of magnitude, as the well was purged from 0 to 1 well volume. There was no significant change in the concentrations of 1,3-DNB, tetryl, 2,4,6-TNT, 2A-DNT and 4A-DNT from 0 to 1 well volume. Figures 8 and 9 illustrate the sharp decrease in analyte concentrations after two well volumes were removed. The analyte concentrations dropped two orders of magnitude for HMX, RDX, 1,3,5-TNB, 2,4,6-TNT and 2,4-DNT. 1,3-DNB concentrations dropped from 0.9 ug/L at 1 well volume to below the detection limit of 0.1 ug/L after two well volumes were removed. As can be seen in Table 6, there was a continual general decrease in analyte concentrations as 3, 4 and 5 well volumes were removed, but not as significant as the decrease between 1 and 2 well volumes.

Post-purge bailer samples

The post-purge bailer samples were taken approximately 16 hours after the submersible pump had been turned off and removed from well 4-8 (Table 5). The post-purge bailer samples were usually 1 to 2 orders of magnitude less than the pre-purge bailer samples and the 0, 0.5 and 1 volume purge samples. The highest contaminant concentrations are also the top sample except for RDX where the middle sample was the highest. The top sample concentration was usually an order of magnitude higher than the bottom sample. Low concentrations of tetryl and 1,3-DNB were detected in the top sample but the middle and bottom samples were below the detection limit. The middle and bottom samples had concentrations similar to the 2 thru 5 volume purge samples, except for RDX and 2,4,6-TNT which had higher values. Unlike the pre-purge bailer samples, the concentration of HMX, 1,3,5-TNB, 2,4,6-TNT, 2,4-DNT, 2A-DNT and 4A-DNT in the bottom post-purge bailer sample were slightly higher than the top sample.

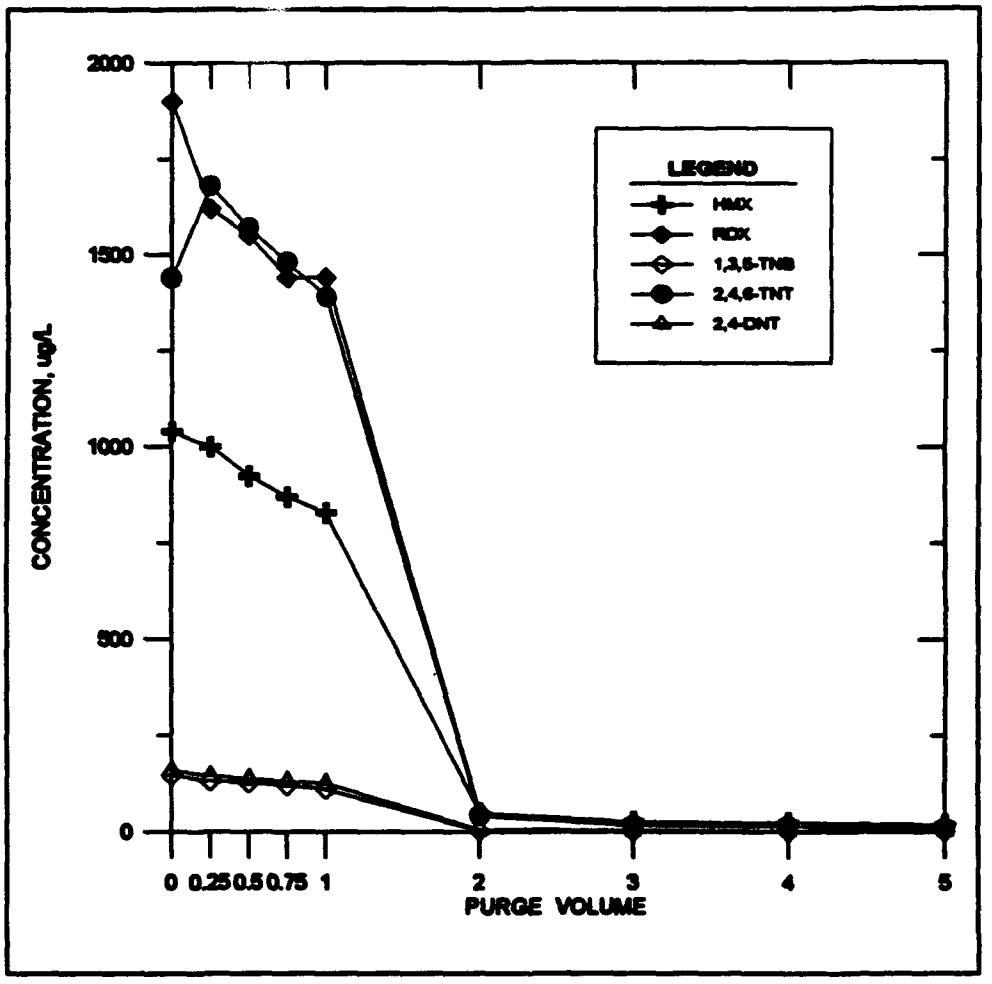

Figure 8. Concentration of HMX, RDX, 1,3,5-TNB, 2,4,6-TNT and 2,4-DNT in well 4-8 purge samples

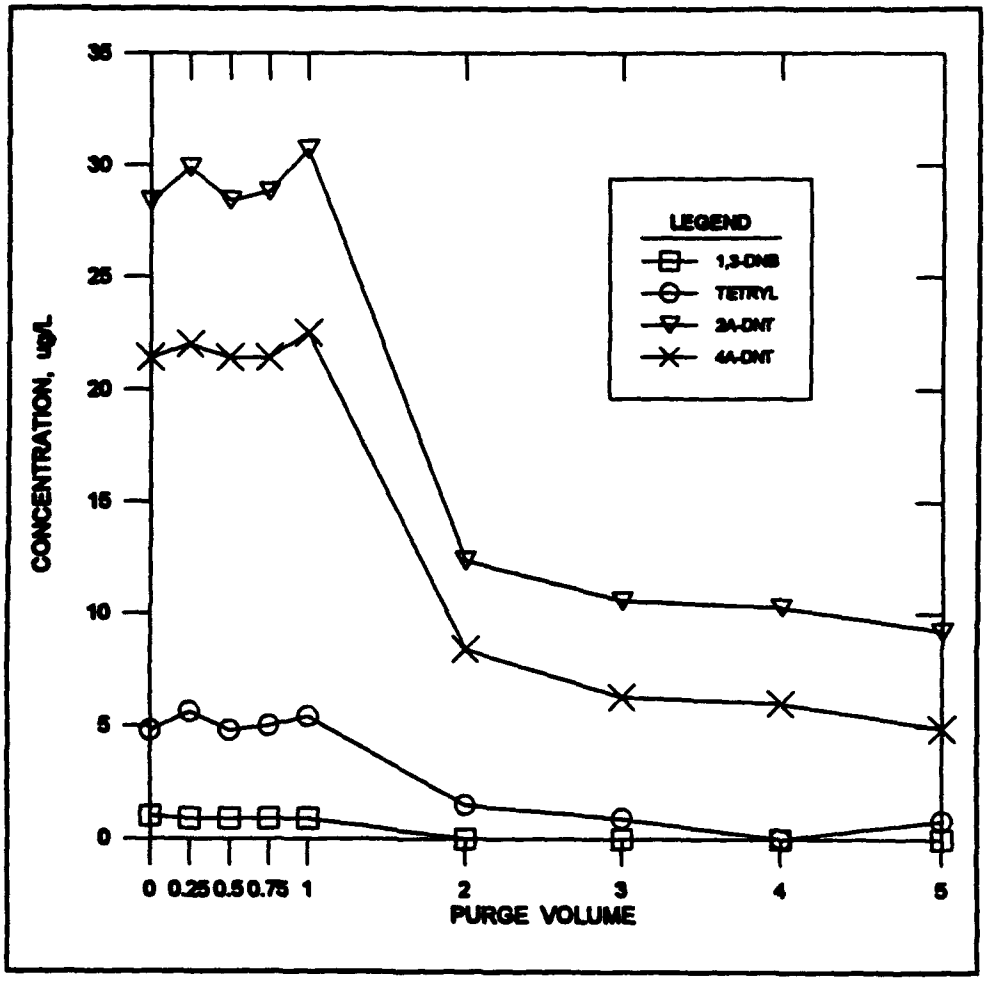

Figure 9. Concentration of 1,3-TNB, tetryl, 2A-DNT and 4A-DNT in well 4-8 purge samples

Well 4-9

Pre-purge point source bailer samples were taken from 1100 to 1130 hours on 16 February 1993 (Table 5). A 0 volume purge sample was taken at 1455 hours on 16 February 1993 with a submersible pump but sampling was suspended due to pump failure. The well purge was restarted on 17 February 1993 and sampled from 0810 to 1050 hours. A 0 volume sample was collected on 17 February. The post-purge bailer samples were taken from 0700 to 0730 hours on 18 February 1993. A bailer sample was taken at a depth of 156 feet (top of water column), 241 feet (middle of water column) and 330 feet (bottom of water column). The bottom bailer sample was taken in the well screen. The chemical data are listed in Appendix B and discussed below.

Pre-purge bailer samples

HMX, RDX, 1,3,5-TNB, tetryl and 2,4,6-TNT were the only explosives detected in the pre-purge bailer samples (Table 7). The tetryl and 2,4,6-TNT values (0.2 J) are estimated values. 1,3-DNB, 2,4-DNT, 2,6-DNT, 2A-DNT, 4A-DNT and NB were not detected in any of the pre-purge, purge or post-purge samples. The RDX, HMX and 1,3,5-TNB concentrations were uniform throughout the water column. HMX ranged from 1.9 ug/L in the top sample to 2 ug/L in the bottom sample while 1,3,5-TNB ranged from 4 to 3.6 ug/L, top to bottom, respectively. RDX ranged from 2,690 ug/L in the top sample to 2,380 ug/L in the bottom sample. Figures 10 and 11 show relationships between analyte concentrations and depths sampled.

Purge samples

HMX, RDX, 1,3,5-TNB, and 2,4,6-TNT were the only analytes detected in the purge samples. 2,4,6-TNT was detected only once at 1.1 ug/L in the 0.25 volume sample. The analyte concentrations in the 0 volume sample (sample 0*, Table 7) taken on 16 February 1993 are similar to the pre-purge concentrations, while the concentrations for the 0 volume sample taken on 17 February 1993 are slightly lower than the pre-purge and 0* purge samples. The HMX values decreased from 1.8 ug/L in the 0 volume sample to below detection limit in the 0.75 volume sample. 1,3,5-TNB decreased from 3.2 ug/L in the 0 volume sample to below detection limit in the 1 volume sample. RDX decreased from 2,120 ug/L in the 0 volume sample, to 361 ug/L in the 0.75 volume sample, and to 5 ug/L in the 4 volume sample. Figure 12 and 13 illustrates the decrease in analyte concentrations during purging.

Post-purge bailer samples

HMX and RDX were the only two analytes detected in the post-purge bailer samples and HMX was detected only in the top sample at 0.5 ug/L. RDX values decreased from 434 ug/L, to 77.8 ug/L, to 15.4 ug/L in the top, middle and bottom samples, respectively (Figure 10 and 11).

Table 7
Well 4-9 Explosives Data for Bailer and Purge Samples

Sample	Analytes, ug/L				
	HMX	RDX	1,3,5- TNB	Tetryl	2,4,6-TNT
156 -B	1.9	2,690	4	<	0.2 J
241 -B	2.2	2,360	3.1	0.2 J	0.2 J
330 -B	2	2,380	3.6	<	<
(0˚) -VP	2.3	2,510	4.7	<	<
0 -VP	1.8	2,120	3.2	<	<
0.25 -VP	1.4	1,720	3	<	1.1
0.50 -VP	0.6	1,720	1	<	<
0.75 -VP	<	361	0.5	<	<
1 -VP	<	81.7	<	<	<
2 -VP	<	5.1	<	<	<
3 -VP	<	4	<	<	<
4 -VP	<	5	<	<	<
156 -A	0.5	434	<	<	<
241 -A	<	77.8	<	<	<
330 -A	<	15.4	<	<	<

B -- Point source bailer samples taken 16 February 1993 before purging
VP -- Volume purged before sampling on 17 February 1993
A -- Point source bailer samples taken 18 February 1993 after purging
< -- Below detection limits of 0.1 ug/L
J -- Estimated value
(0˚) --- sampled on 16 February 1993
1,3-DNB, 2,4-DNT, 2,6-DNT, 2A-DNT, 4A-DNT and NB below detection limit in all samples

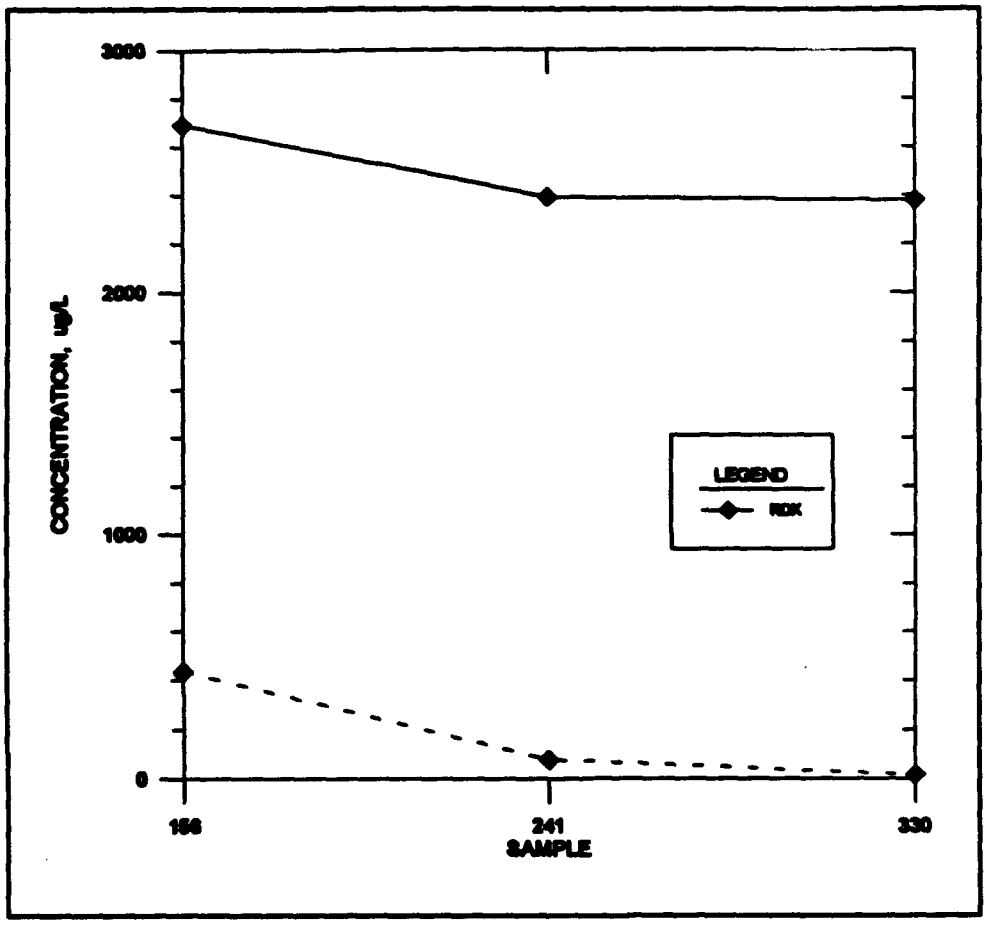

Figure 10. Concentration of RDX in well 4-9 pre- (solid line) and post-purge (dashed line) bailer samples

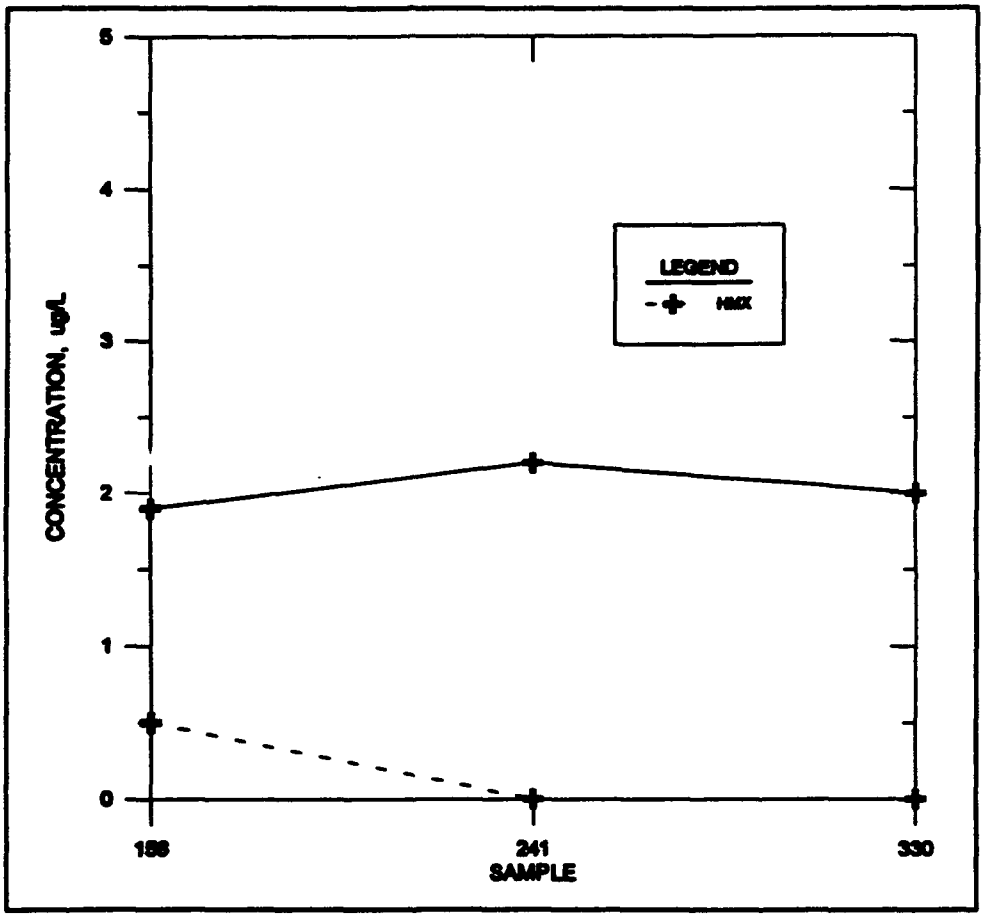

Figure 11. Concentration of HMX in well 4-9 pre- (solid line) and post-purge (dashed line) bailer samples

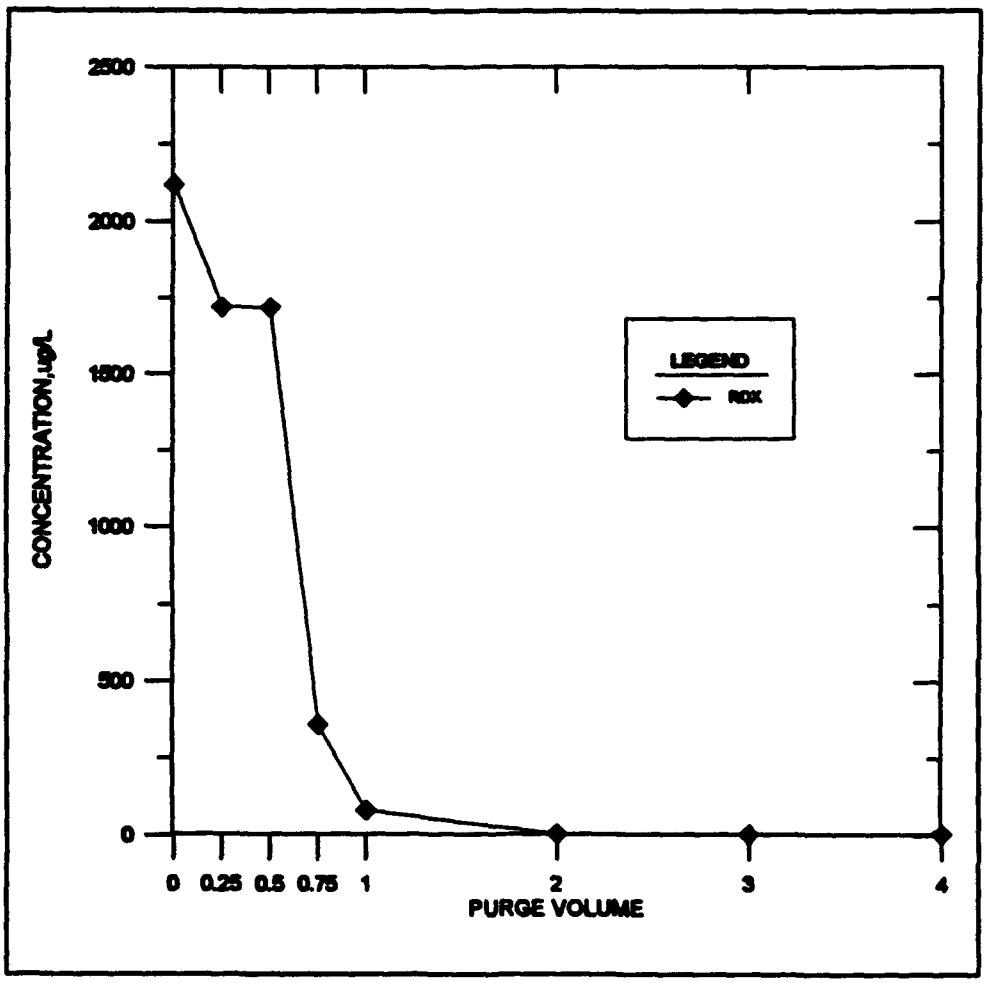

Figure 12. Concentration of RDX in well 4-9 purge samples

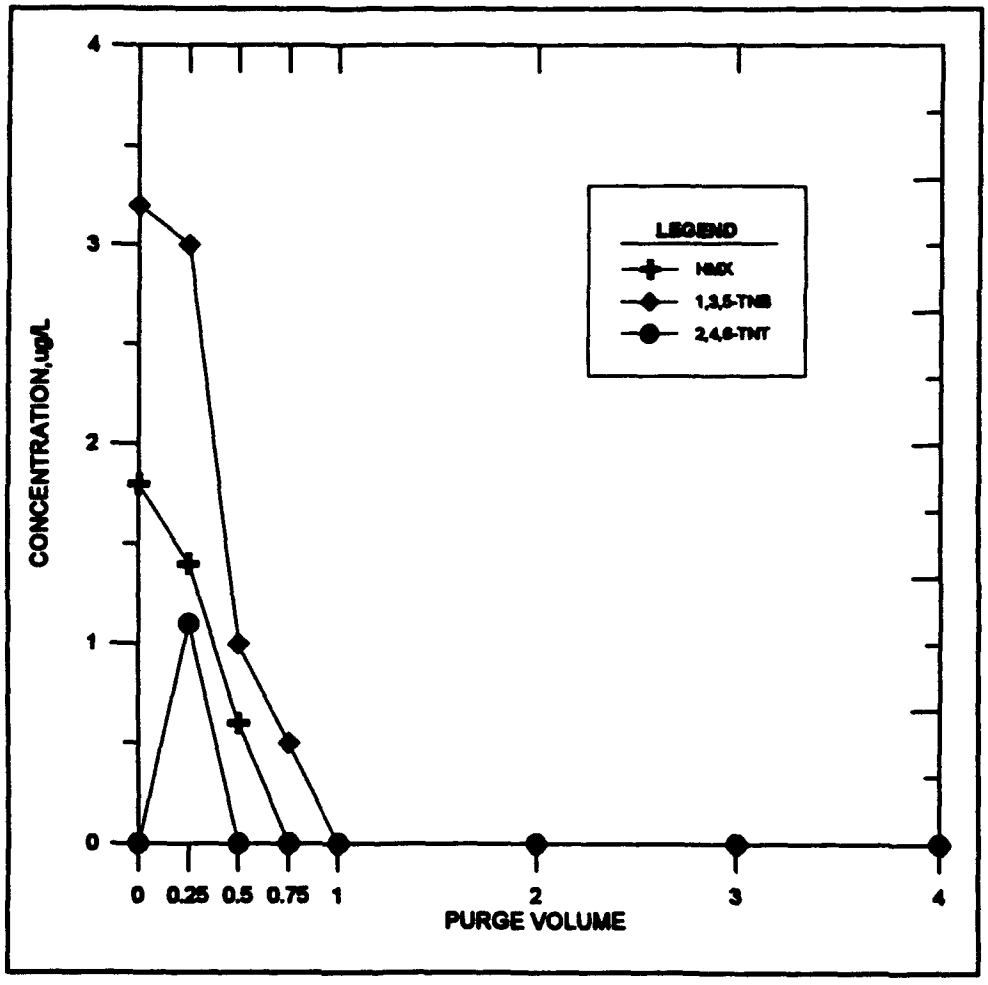

Figure 13. Concentration of HMX, 1,3,5-TNB and 2,4,6-TNT in well 4-9 purge samples

5 Discussion

The explosive contaminants in wells 4-8 and 4-9 are in higher concentrations at the top of the water column than in the screened area of the wells indicating the contaminants are entering the monitor wells at or above the top of the water column. The decrease in the concentration of the explosives as the wells were purged verifies the contaminants are not coming from the Selah Interbed aquifer where the wells are screened, but are entering the wells through the well casing in the upper part of the wells.

The concentration of explosives in the pre- and post-purge bailer samples indicate the contaminants are entering the wells at a relative slow rate. The explosives in the top, middle and bottom pre-purge bailer samples are usually an order of magnitude higher than the post-purge bailer samples which were taken 16 (well 4-8) and 19 (well 4-9) hours after the wells were purged.

The explosives chemical data from the February 1993 purge and pre- and post-purge bailer samples indicate explosives were leaking into wells 4-8 and 4-9 through a crack and/or a casing joint in the PVC casing located near the top of the water column in both wells. Video tapes of wells 4-8 and 4-9 were made in August 1993 to see if the leaks in the PVC casings could be identified. A visible leak was detected at a casing joint in each well. The casing joint located 73 ft below ground surface in well 4-8 and 147 ft below ground surface in well 4-9 was leaking. The observed leaks in each well would produce an estimated 1 to 5 gallons of water a day.

The video tapes show the casing joints in wells 4-8 and 4-9 usually appear as tight, hardly visible joints on one side of the casing and as very small visible seams or openings on the opposite side of the casing. There is no visible evidence of any cracks in the PVC pipe at the joints or elsewhere. The weight of the well casing (283 ft and 338 ft for wells 4-8 and 4-9, respectively), including the well screen, on the casing joints as the wells were being installed, could have stretched or possibly cracked some of the casing joints enough to cause them to leak.

The visible leaking joints are located in the alluvium. Bentonite grout (Volclay grout in well 4-8 and bentonite powder in well 4-9) was used instead of cement-bentonite grout to grout the wells from the top of the filter packs to the top of the water table in the alluvial aquifer. Benonite grout was used

instead of cement-bentonite grout because the weight of a column of cement-bentonite grout and the heat generated as cement-bentonite grout set up may have collapsed schedule 40 PVC casing. The leaks in the casing joints indicate the alluvium is in direct contact with the PVC casing, at least in the areas where the joints are leaking. The collapse of the alluvial sands and gravels as the metal casings were being removed evidently pushed the bentonite grout away from the PVC casing.

The Army is preparing plans to have wells 4-8, 4-9 and two other wells screened in the Selah Interbed aquifer removed in 1994. The wells are to be drilled out and the boreholes filled with bentonite-cement grout to prevent groundwater leakage from the alluvial aquifer into the basalt aquifers.

6 Conclusions

The highest concentration of contaminants were in the samples taken at the top of the water column in wells 4-8 and 4-9. The concentration of contaminants dropped 2 to 3 orders of magnitude after 2 to 3 well casing volumes were purged from wells 4-8 and 4-9. The highest contaminant levels in the pre- and post-purge bailer samples were at the top of the water column in both wells. These data show the contaminants were not coming from the Selah Interbed Aquifer, but were entering the well casings through a crack in the PVC casing or casing joints at or above the piezometric elevation of the Selah Interbed aquifer. The increase in contaminant concentrations from the time the last well purge samples were taken until the top post-purge bailer samples were taken indicate the rate of leakage into the wells is very low.

The alluvial and Rattlesnake Ridge Interbed aquifers are two possible sources of water that could leak into wells 4-8 and 4-9. The contaminated alluvial water table aquifer is at a higher elevation than the piezometric surface of the Selah Interbed aquifer thus facilitating leakage into the monitor wells screened in the Selah Interbed. Monitor wells installed in the Rattlesnake Ridge Interbed aquifer at well clusters 4-8 and 4-9 (Dames and Moore, 1993) show the Rattlesnake Ridge Interbed aquifer is a confined aquifer with water level elevations similar to those in the Selah Interbed aquifer, however no explosive contaminants were detected in the monitor wells screened in the Rattlesnake Ridge Interbed aquifer.

The explosive contaminants in wells 4-8 and 4-9 appears to be leaking into the wells from the alluvial aquifer through a crack in the casing and/or a casing joint. The leak is at or above the piezometric surface in both wells.

7 Lessons Learned

Once a ground water monitor well is installed, defects in the well can not be easily detected from the ground surface without using a video camera. A collapsed casing or screen is usually easily detected because of physical problems with sampling. A leak in a well casing screened below the water table or in a different aquifer is not as evident. The leaks in well 4-8 and 4-9 were first indicated by erratic changes in chemical data and changes in color of the water during well purging.

Any erratic change in chemical data should be very carefully reviewed to determine why the change occurred. Some examples of erratic change could be:

- order of magnitude changes in concentration between sampling rounds;
- concentration ranges variable in one well and uniform in other wells screened in the same zone;
- changes in analytes over several sampling rounds.

Detailed field notes describing all aspects of the sampling procedure should be kept for each well. Anything that makes a well different from other wells screened in the same aquifer could indicate possible problems with the well casing. Some examples of physical changes are:

- color changes during purging or sampling;
- odors;
- increases in volume of sediment;
- temperature changes.

Schedule 80 PVC casing should be used for monitor wells that are 100 ft or deeper. The thicker casing will be stronger at the joints to support the weight of the casing as the well is being installed. The thicker casing will probably not be affected as much by the heat generated as a cement-bentonite grout cures or the weight of the cement-bentonite grout column.

If a well is to be installed in or through a coarse granular material, such as large gravels or cobbles, that will collapse as a drilling casing is being removed during well installation, a permanent casing of at least 4 to 6 inches greater diameter than the well casing should be installed through the granular

material. The permanent casing will seal off that portion of the aquifer preventing the granular material from collapsing on the well casing. If a permanent casing is not used, schedule 80 PVC well casing would be preferable to prevent the collapse of the coarse granular material from damaging the well casing as the drill casing is removed.

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Appendix A
Explosives Chemical Data from IRDMIS

WELL	ANALYTE	SAMPLE DATE	BOOL.[1]	MEASURED VALUE, ug/L	
9	246TNT	22-apr-1981		1.10	04
9	246TNT	15-jul-1981		8.60	03
9	246TNT	04-nov-1981		6.10	03
9	24DNT	22-apr-1981	LT	4.80	-01
9	24DNT	15-jul-1981		4.50	00
9	24DNT	04-nov-1981		3.80	00
9	26DNT	22-apr-1981		7.60	02
9	26DNT	15-jul-1981		6.80	02
9	26DNT	04-nov-1981		3.90	02
9	RDX	22-apr-1981		1.00	04
9	RDX	15-jul-1981		1.80	03
9	RDX	04-nov-1981		1.50	03
9	TETRYL	22-apr-1981	LT	9.80	-01
9	TETRYL	15-jul-1981	LT	9.80	-01
9	TETRYL	04-nov-1981	LT	9.80	-01
9	135TNB	07-jul-1988		4.20	02
9	13DNB	07-jul-1988	LT	6.10	-01
9	246TNT	07-jul-1988		3.40	03
9	24DNT	07-jul-1988		3.30	02
9	26DNT	07-jul-1988		5.30	00
9	HMX	07-jul-1988		1.40	03
9	NB	07-jul-1988	LT	1.13	00
9	RDX	07-jul-1988		5.70	03
9	TETRYL	07-jul-1988	LT	1.23	01
9	135TNB	08-nov-1990		4.20	02
9	135TNB	19-feb-1991		4.40	02
9	13DNB	08-nov-1990		1.79	01
9	13DNB	19-feb-1991		8.82	00
9	246TNT	08-nov-1990		3.10	03
9	246TNT	19-feb-1991		3.20	03
9	24DNT	08-nov-1990		3.40	02
9	24DNT	19-feb-1991		4.30	02
9	26DNT	08-nov-1990	LT	1.15	00
9	26DNT	19-feb-1991	LT	1.15	00
9	HMX	08-nov-1990		5.90	02
9	HMX	19-feb-1991		1.30	03
9	NB	08-nov-1990		1.57	01
9	NB	19-feb-1991	LT	1.07	00
9	RDX	08-nov-1990		2.80	03
9	TETRYL	08-nov-1990	LT	5.56	-01

WELL	ANALYTE	SAMPLE DATE	BOOL.[1]	MEASURED VALUE, ug/L	
9	TETRYL	19-feb-1991	LT	5.56	-01
9	135TNB	15-dec-1992		2.60	02
9	13DNB	15-dec-1992		4.67	00
9	246TNT	15-dec-1992		2.90	03
9	24DNT	15-dec-1992		3.20	02
9	26DNT	15-dec-1992		7.76	00
9	HMX	15-dec-1992		1.30	03
9	NB	15-dec-1992	LT	6.45	-01
9	RDX	15-dec-1992		2.30	03
9	TETRYL	15-dec-1992		8.53	00
4-8	135TNB	16-oct-1990	LT	6.26	-01
4-8	135TNB	28-feb-1991		3.92	01
4-8	13DNB	16-oct-1990	LT	5.19	-01
4-8	13DNB	28-feb-1991		8.53	-01
4-8	246TNT	16-oct-1990		8.34	-01
4-8	246TNT	28-feb-1991		3.90	02
4-8	24DNT	16-oct-1990		1.48	00
4-8	24DNT	28-feb-1991		6.00	01
4-8	26DNT	16-oct-1990	LT	1.15	00
4-8	26DNT	28-feb-1991	LT	1.15	00
4-8	HMX	16-oct-1990		1.08	01
4-8	HMX	28-feb-1991		3.50	02
4-8	NB	16-oct-1990	LT	1.07	00
4-8	NB	28-feb-1991	LT	1.07	00
4-8	RDX	16-oct-1990		4.48	01
4-8	RDX	28-feb-1991		6.50	02
4-8	TETRYL	16-oct-1990	LT	5.56	-01
4-8	TETRYL	28-feb-1991	LT	5.56	-01
4-8	135TNB	11-oct-1992		2.60	02
4-8	135TNB	02-dec-1992		2.96	01
4-8	135TNB	16-dec-1992		1.10	00
4-8	135TNB	17-dec-1992		1.80	01
4-8	13DNB	11-oct-1992	LT	6.10	00
4-8	13DNB	02-dec-1992	LT	6.11	-01
4-8	13DNB	16-dec-1992	LT	6.11	-01
4-8	13DNB	17-dec-1992	LT	6.11	-01
4-8	246TNT	11-oct-1992		1.90	03
4-8	246TNT	02-dec-1992		3.50	02
4-8	246TNT	16-dec-1992		8.95	00
4-8	246TNT	17-dec-1992		1.90	02
4-8	24DNT	11-oct-1992		2.80	02
4-8	24DNT	02-dec-1992		4.10	01
4-8	24DNT	16-dec-1992		3.67	00
4-8	24DNT	17-dec-1992		2.23	01
4-8	26DNT	11-oct-1992	LT	7.40	-01
4-8	26DNT	02-dec-1992	LT	7.38	-02
4-8	26DNT	16-dec-1992	LT	7.38	-02
4-8	26DNT	17-dec-1992	LT	7.38	-02
4-8	HMX	11-oct-1992		1.50	03
4-8	HMX	02-dec-1992		2.80	02
4-8	HMX	16-dec-1992		2.58	01
4-8	HMX	17-dec-1992		1.20	02
4-8	NB	11-oct-1992	LT	6.40	00
4-8	NB	02-dec-1992	LT	6.45	-01
4-8	NB	16-dec-1992		2.33	00
4-8	NB	17-dec-1992	LT	6.45	-01
4-8	RDX	11-oct-1992		3.30	03
4-8	RDX	02-dec-1992		4.20	02
4-8	RDX	16-dec-1992		5.03	00

WELL	ANALYTE	SAMPLE DATE	BOOL[1]	MEASURED VALUE, ug/L	
4-8	RDX	17-dec-1992		1.70	02
4-8	TETRYL	11-oct-1992	LT	2.50	01
4-8	TETRYL	02-dec-1992	LT	2.49	00
4-8	TETRYL	16-dec-1992	LT	1.56	00
4-8	TETRYL	17-dec-1992	LT	1.56	00
4-9	135TNB	21-oct-1990	LT	6.26	-01
4-9	135TNB	01-mar-1991		7.76	-01
4-9	135TNB	01-mar-1991	LT	6.26	-01
4-9	13DNB	21-oct-1990	LT	5.19	-01
4-9	13DNB	01-mar-1991		1.01	00
4-9	13DNB	01-mar-1991	LT	5.19	-01
4-9	246TNT	21-oct-1990		1.67	00
4-9	246TNT	01-mar-1991	LT	5.88	-01
4-9	24DNT	21-oct-1990	LT	6.12	-01
4-9	24DNT	01-mar-1991	LT	6.12	-01
4-9	26DNT	21-oct-1990	LT	1.15	00
4-9	26DNT	01-mar-1991	LT	1.15	00
4-9	HMX	21-oct-1990		1.86	00
4-9	HMX	01-mar-1991		7.89	00
4-9	HMX	01-mar-1991		8.30	00
4-9	NB	21-oct-1990	LT	1.07	00
4-9	NB	01-mar-1991	LT	1.07	00
4-9	RDX	21-oct-1990		1.10	03
4-9	RDX	01-mar-1991		4.70	03
4-9	RDX	01-mar-1991		5.60	03
4-9	TETRYL	21-oct-1990	LT	5.56	-01
4-9	TETRYL	01-mar-1991	LT	5.56	-01
4-9	135TNB	11-oct-1992		1.51	00
4-9	135TNB	11-oct-1992		2.75	00
4-9	135TNB	03-dec-1992		6.92	-01
4-9	13DNB	11-oct-1992	LT	6.11	-01
4-9	13DNB	03-dec-1992	LT	6.11	-01
4-9	246TNT	11-oct-1992		3.26	00
4-9	246TNT	11-oct-1992		4.43	00
4-9	246TNT	03-dec-1992		4.02	00
4-9	24DNT	11-oct-1992		5.46	-01
4-9	24DNT	11-oct-1992		7.26	-01
4-9	24DNT	03-dec-1992		3.11	-01
4-9	26DNT	11-oct-1992	LT	7.38	-02
4-9	26DNT	03-dec-1992	LT	7.38	-02
4-9	HMX	11-oct-1992		2.00	01
4-9	HMX	11-oct-1992		2.60	01
4-9	HMX	03-dec-1992		1.54	00
4-9	NB	03-dec-1992	LT	6.45	-01
4-9	RDX	11-oct-1992		9.20	02
4-9	RDX	11-oct-1992		4.40	03
4-9	RDX	03-dec-1992		2.70	02
4-9	TETRYL	11-oct-1992	LT	2.49	00
4-9	TETRYL	03-dec-1992	LT	2.49	00
MW-28	135TNB	17-jun-1988	LT	5.60	-01
MW-28	13DNB	17-jun-1988	LT	6.10	-01
MW-28	246TNT	17-jun-1988	LT	7.80	-01
MW-28	24DNT	17-jun-1988	LT	6.00	-01
MW-28	26DNT	17-jun-1988	LT	5.50	-01
MW-28	HMX	17-jun-1988	LT	1.30	00
MW-28	NB	17-jun-1988	LT	1.13	00
MW-28	RDX	17-jun-1988		1.00	03
MW-28	TETRYL	17-jun-1988	LT	6.60	-01
MW-28	135TNB	05-nov-1990		2.40	00

WELL	ANALYTE	SAMPLE DATE	BOOL.[1]	MEASURED VALUE, ug/L	
MW-28	135TNB	14-feb-1991		3.37	00
MW-28	135TNB	14-feb-1991		3.38	00
MW-28	13DNB	05-nov-1990		1.57	00
MW-28	13DNB	14-feb-1991		6.44	-01
MW-28	13DNB	14-feb-1991	LT	5.19	-01
MW-28	246TNT	05-nov-1990	LT	5.88	-01
MW-28	246TNT	14-feb-1991	LT	5.88	-01
MW-28	24DNT	05-nov-1990	LT	6.12	-01
MW-28	24DNT	14-feb-1991	LT	6.12	-01
MW-28	26DNT	05-nov-1990	LT	1.15	00
MW-28	26DNT	14-feb-1991	LT	1.15	00
MW-28	HMX	05-nov-1990		1.56	01
MW-28	HMX	14-feb-1991		1.74	01
MW-28	HMX	14-feb-1991		2.01	01
MW-28	NB	05-nov-1990	LT	1.07	00
MW-28	NB	14-feb-1991	LT	1.07	00
MW-28	RDX	05-nov-1990		5.00	03
MW-28	RDX	14-feb-1991		2.10	03
MW-28	RDX	14-feb-1991		6.80	03
MW-28	TETRYL	05-nov-1990	LT	5.56	-01
MW-28	TETRYL	14-feb-1991	LT	5.56	-01
MW-28	135TNB	04-dec-1992		4.44	00
MW-28	13DNB	04-dec-1992		1.03	00
MW-28	246TNT	04-dec-1992	LT	6.35	-01
MW-28	24DNT	04-dec-1992		2.26	-01
MW-28	26DNT	04-dec-1992		1.05	-01
MW-28	HMX	04-dec-1992		6.00	01
MW-28	NB	04-dec-1992	LT	6.45	-01
MW-28	RDX	04-dec-1992		3.20	03
MW-28	TETRYL	04-dec-1992	LT	2.49	00
SB-3	135TNB	16-jun-1988	LT	5.60	-01
SB-3	13DNB	16-jun-1988	LT	6.10	-01
SB-3	246TNT	16-jun-1988	LT	7.80	-01
SB-3	24DNT	16-jun-1988	LT	6.00	-01
SB-3	26DNT	16-jun-1988	LT	5.50	-01
SB-3	HMX	16-jun-1988	LT	1.30	00
SB-3	NB	16-jun-1988	LT	1.13	00
SB-3	RDX	16-jun-1988		6.50	-01
SB-3	TETRYL	16-jun-1988	LT	6.60	-01
SB-3	135TNB	04-nov-1990	LT	6.26	-01
SB-3	135TNB	19-feb-1991	LT	6.26	-01
SB-3	13DNB	04-nov-1990	LT	5.19	-01
SB-3	13DNB	19-feb-1991	LT	5.19	-01
SB-3	246TNT	04-nov-1990	LT	5.88	-01
SB-3	246TNT	19-feb-1991	LT	5.88	-01
SB-3	24DNT	04-nov-1990	LT	6.12	-01
SB-3	24DNT	19-feb-1991	LT	6.12	-01
SB-3	26DNT	04-nov-1990	LT	1.15	00
SB-3	26DNT	19-feb-1991	LT	1.15	00
SB-3	HMX	04-nov-1990	LT	1.65	00
SB-3	HMX	19-feb-1991	LT	1.65	00
SB-3	NB	04-nov-1990	LT	1.07	00
SB-3	NB	19-feb-1991	LT	1.07	00
SB-3	RDX	04-nov-1990		8.26	00
SB-3	RDX	19-feb-1991		5.32	00
SB-3	TETRYL	04-nov-1990	LT	5.56	-01
SB-3	TETRYL	19-feb-1991	LT	5.56	-01
SB-3	135TNB	09-dec-1992		4.60	-01
SB-3	13DNB	09-dec-1992	LT	6.11	-01

WELL	ANALYTE	SAMPLE DATE	BOOL[1]	MEASURED VALUE, ug/L	
SB-3	246TNT	09-dec-1992	LT	6.35	-01
SB-3	24DNT	09-dec-1992	LT	6.37	-02
SB-3	26DNT	09-dec-1992	LT	7.38	-02
SB-3	HMX	09-dec-1992	LT	1.21	00
SB-3	NB	09-dec-1992	LT	6.45	-01
SB-3	RDX	09-dec-1992		4.03	00
SB-3	TETRYL	09-dec-1992	LT	2.49	00

BOOL[1] — "LT" indicates below detection limit
MEASURED VALUE, ug/L — value such as "1.10 04" equal 11,000 ug/L

Appendix B
Explosives Chemical Data for Wells 4-8 and 4-9 February 1993 Bailer & Purge Samples

WELL No.	SAMPLE DATE 1993	FIELD SAMPLE No.	REPORT SAMPLE No.	ANALYTE	MEASURED VALUE mg/L
Well 4-8	17 Feb	SAMPLE 1310	122 - B	Nitrobenzene	< .0001
Well 4-8	17 Feb	SAMPLE 1310	122 - B	HMX	1.32
Well 4-8	17 Feb	SAMPLE 1310	122 - B	RDX	1.93
Well 4-8	17 Feb	SAMPLE 1310	122 - B	TNB	.155
Well 4-8	17 Feb	SAMPLE 1310	122 - B	DNB	.001
Well 4-8	17 Feb	SAMPLE 1310	122 - B	TETRYL	.006
Well 4-8	17 Feb	SAMPLE 1310	122 - B	TNT	1.54
Well 4-8	17 Feb	SAMPLE 1310	122 - B	2,4-DNT	.164
Well 4-8	17 Feb	SAMPLE 1310	122 - B	2,6-DNT	< .0001
Well 4-8	17 Feb	SAMPLE 1310	122 - B	2-AMINO-4,6-DINITROTOLUENE	.0322
Well 4-8	17 Feb	SAMPLE 1310	122 - B	4-AMINO-2,6-DINITROTOLUENE	.0266
Well 4-8	17 Feb	SAMPLE 1320	202 - B	Nitrobenzene	< .0001
Well 4-8	17 Feb	SAMPLE 1320	202 - B	HMX	1.04
Well 4-8	17 Feb	SAMPLE 1320	202 - B	RDX	1.78
Well 4-8	17 Feb	SAMPLE 1320	202 - B	TNB	.146
Well 4-8	17 Feb	SAMPLE 1320	202 - B	DNB	.001
Well 4-8	17 Feb	SAMPLE 1320	202 - B	TETRYL	.0054
Well 4-8	17 Feb	SAMPLE 1320	202 - B	TNT	1.81
Well 4-8	17 Feb	SAMPLE 1320	202 - B	2,4-DNT	.156
Well 4-8	17 Feb	SAMPLE 1320	202 - B	2,6-DNT	< .0001
Well 4-8	17 Feb	SAMPLE 1320	202 - B	2-AMINO-4,6-DINITROTOLUENE	.0293
Well 4-8	17 Feb	SAMPLE 1320	202 - B	4-AMINO-2,6-DINITROTOLUENE	.0223
Well 4-8	17 Feb	SAMPLE 1330	280 - B	Nitrobenzene	< .0001
Well 4-8	17 Feb	SAMPLE 1330	280 - B	HMX	.937
Well 4-8	17 Feb	SAMPLE 1330	280 - B	RDX	1.57
Well 4-8	17 Feb	SAMPLE 1330	280 - B	TNB	.131
Well 4-8	17 Feb	SAMPLE 1330	280 - B	DNB	.0006
Well 4-8	17 Feb	SAMPLE 1330	280 - B	TETRYL	.005
Well 4-8	17 Feb	SAMPLE 1330	280 - B	TNT	1.65
Well 4-8	17 Feb	SAMPLE 1330	280 - B	2,4-DNT	.141
Well 4-8	17 Feb	SAMPLE 1330	280 - B	2,6-DNT	< .0001
Well 4-8	17 Feb	SAMPLE 1330	280 - B	2-AMINO-4,6-DINITROTOLUENE	.028
Well 4-8	17 Feb	SAMPLE 1330	280 - B	4-AMINO-2,6-DINITROTOLUENE	.0213
Well 4-8	17 Feb	SAMPLE 1400	0 - VP	Nitrobenzene	< .0001
Well 4-8	17 Feb	SAMPLE 1400	0 - VP	HMX	1.04
Well 4-8	17 Feb	SAMPLE 1400	0 - VP	RDX	1.9
Well 4-8	17 Feb	SAMPLE 1400	0 - VP	TNB	.146
Well 4-8	17 Feb	SAMPLE 1400	0 - VP	DNB	.001
Well 4-8	17 Feb	SAMPLE 1400	0 - VP	TETRYL	.0048
Well 4-8	17 Feb	SAMPLE 1400	0 - VP	TNT	1.44
Well 4-8	17 Feb	SAMPLE 1400	0 - VP	2,4-DNT	.159

WELL No.	SAMPLE DATE 1993	FIELD SAMPLE No.	REPORT SAMPLE No.	ANALYTE	MEASURED VALUE mg/L
Well 4-8	17 Feb	SAMPLE 1400	0 - VP	2,6-DNT	< .0001
Well 4-8	17 Feb	SAMPLE 1400	0 - VP	2-AMINO-4,6-DINITROTOLUENE	.0284
Well 4-8	17 Feb	SAMPLE 1400	0 - VP	4-AMINO-2,6-DINITROTOLUENE	.0214
Well 4-8	17 Feb	SAMPLE 1415	0.25 - VP	Nitrobenzene	< .0001
Well 4-8	17 Feb	SAMPLE 1415	0.25 - VP	HMX	1
Well 4-8	17 Feb	SAMPLE 1415	0.25 - VP	RDX	1.62
Well 4-8	17 Feb	SAMPLE 1415	0.25 - VP	TNB	.131
Well 4-8	17 Feb	SAMPLE 1415	0.25 - VP	DNB	.0009
Well 4-8	17 Feb	SAMPLE 1415	0.25 - VP	TETRYL	.0056
Well 4-8	17 Feb	SAMPLE 1415	0.25 - VP	TNT	1.68
Well 4-8	17 Feb	SAMPLE 1415	0.25 - VP	2,4-DNT	.144
Well 4-8	17 Feb	SAMPLE 1415	0.25 - VP	2,6-DNT	< .0001
Well 4-8	17 Feb	SAMPLE 1415	0.25 - VP	2-AMINO-4,6-DINITROTOLUENE	.0299
Well 4-8	17 Feb	SAMPLE 1415	0.25 - VP	4-AMINO-2,6-DINITROTOLUENE	.022
Well 4-8	17 Feb	SAMPLE 1405	0.50 - VP	Nitrobenzene	< .0001
Well 4-8	17 Feb	SAMPLE 1405	0.50 - VP	HMX	.924
Well 4-8	17 Feb	SAMPLE 1405	0.50 - VP	RDX	1.55
Well 4-8	17 Feb	SAMPLE 1405	0.50 - VP	TNB	.126
Well 4-8	17 Feb	SAMPLE 1405	0.50 - VP	DNB	.0009
Well 4-8	17 Feb	SAMPLE 1405	0.50 - VP	TETRYL	.0048
Well 4-8	17 Feb	SAMPLE 1405	0.50 - VP	TNT	1.57
Well 4-8	17 Feb	SAMPLE 1405	0.50 - VP	2,4-DNT	.136
Well 4-8	17 Feb	SAMPLE 1405	0.50 - VP	2,6-DNT	< .0001
Well 4-8	17 Feb	SAMPLE 1405	0.50 - VP	2-AMINO-4,6-DINITROTOLUENE	.0284
Well 4-8	17 Feb	SAMPLE 1405	0.50 - VP	4-AMINO-2,6-DINITROTOLUENE	.0214
Well 4-8	17 Feb	SAMPLE 1410	0.75 - VP	Nitrobenzene	< .0001
Well 4-8	17 Feb	SAMPLE 1410	0.75 - VP	HMX	.87
Well 4-8	17 Feb	SAMPLE 1410	0.75 - VP	RDX	1.44
Well 4-8	17 Feb	SAMPLE 1410	0.75 - VP	TNB	.119
Well 4-8	17 Feb	SAMPLE 1410	0.75 - VP	DNB	.0009
Well 4-8	17 Feb	SAMPLE 1410	0.75 - VP	TETRYL	.005
Well 4-8	17 Feb	SAMPLE 1410	0.75 - VP	TNT	1.48
Well 4-8	17 Feb	SAMPLE 1410	0.75 - VP	2,4-DNT	.13
Well 4-8	17 Feb	SAMPLE 1410	0.75 - VP	2,6-DNT	< .0001
Well 4-8	17 Feb	SAMPLE 1410	0.75 - VP	2-AMINO-4,6-DINITROTOLUENE	.0288
Well 4-8	17 Feb	SAMPLE 1410	0.75 - VP	4-AMINO-2,6-DINITROTOLUENE	.0214
Well 4-8	17 Feb	SAMPLE 1420	1 - VP	Nitrobenzene	< .0001
Well 4-8	17 Feb	SAMPLE 1420	1 - VP	HMX	.829
Well 4-8	17 Feb	SAMPLE 1420	1 - VP	RDX	1.44
Well 4-8	17 Feb	SAMPLE 1420	1 - VP	TNB	.11
Well 4-8	17 Feb	SAMPLE 1420	1 - VP	DNB	.0009
Well 4-8	17 Feb	SAMPLE 1420	1 - VP	TETRYL	.0054
Well 4-8	17 Feb	SAMPLE 1420	1 - VP	TNT	1.39
Well 4-8	17 Feb	SAMPLE 1420	1 - VP	2,4-DNT	.124
Well 4-8	17 Feb	SAMPLE 1420	1 - VP	2,6-DNT	< .0001
Well 4-8	17 Feb	SAMPLE 1420	1 - VP	2-AMINO-4,6-DINITROTOLUENE	.0307
Well 4-8	17 Feb	SAMPLE 1420	1 - VP	4-AMINO-2,6-DINITROTOLUENE	.0225
Well 4-8	17 Feb	SAMPLE 1447	2 - VP	Nitrobenzene	< .0001
Well 4-8	17 Feb	SAMPLE 1447	2 - VP	HMX	.0477
Well 4-8	17 Feb	SAMPLE 1447	2 - VP	RDX	.0503
Well 4-8	17 Feb	SAMPLE 1447	2 - VP	TNB	.003
Well 4-8	17 Feb	SAMPLE 1447	2 - VP	DNB	< .0001
Well 4-8	17 Feb	SAMPLE 1447	2 - VP	TETRYL	.0015
Well 4-8	17 Feb	SAMPLE 1447	2 - VP	TNT	.0416
Well 4-8	17 Feb	SAMPLE 1447	2 - VP	2,4-DNT	.0065
Well 4-8	17 Feb	SAMPLE 1447	2 - VP	2,6-DNT	< .0001
Well 4-8	17 Feb	SAMPLE 1447	2 - VP	2-AMINO-4,6-DINITROTOLUENE	.0124
Well 4-8	17 Feb	SAMPLE 1447	2 - VP	4-AMINO-2,6-DINITROTOLUENE	.0084
Well 4-8	17 Feb	SAMPLE 1514	3 - VP	Nitrobenzene	< .0001
Well 4-8	17 Feb	SAMPLE 1514	3 - VP	HMX	.0265
Well 4-8	17 Feb	SAMPLE 1514	3 - VP	RDX	.018
Well 4-8	17 Feb	SAMPLE 1514	3 - VP	TNB	.0013
Well 4-8	17 Feb	SAMPLE 1514	3 - VP	DNB	< .0001
Well 4-8	17 Feb	SAMPLE 1514	3 - VP	TETRYL	.0009

WELL No.	SAMPLE DATE 1993	FIELD SAMPLE No.	REPORT SAMPLE No.	ANALYTE	MEASURED VALUE mg/L
Well 4-8	17 Feb	SAMPLE 1514	3 - VP	TNT	.0159
Well 4-8	17 Feb	SAMPLE 1514	3 - VP	2,4-DNT	.004
Well 4-8	17 Feb	SAMPLE 1514	3 - VP	2,6-DNT	< .0001
Well 4-8	17 Feb	SAMPLE 1514	3 - VP	2-AMINO-4,6-DINITROTOLUENE	.0106
Well 4-8	17 Feb	SAMPLE 1514	3 - VP	4-AMINO-2,6-DINITROTOLUENE	.0063
Well 4-8	17 Feb	SAMPLE 1534	4 - VP	Nitrobenzene	< .0001
Well 4-8	17 Feb	SAMPLE 1534	4 - VP	HMX	.0249
Well 4-8	17 Feb	SAMPLE 1534	4 - VP	RDX	.0162
Well 4-8	17 Feb	SAMPLE 1534	4 - VP	TNB	.0013
Well 4-8	17 Feb	SAMPLE 1534	4 - VP	DNB	< .0001
Well 4-8	17 Feb	SAMPLE 1534	4 - VP	TETRYL	< .0001
Well 4-8	17 Feb	SAMPLE 1534	4 - VP	TNT	.0151
Well 4-8	17 Feb	SAMPLE 1534	4 - VP	2,4-DNT	.0036
Well 4-8	17 Feb	SAMPLE 1534	4 - VP	2,6-DNT	< .0001
Well 4-8	17 Feb	SAMPLE 1534	4 - VP	2-AMINO-4,6-DINITROTOLUENE	.0103
Well 4-8	17 Feb	SAMPLE 1534	4 - VP	4-AMINO-2,6-DINITROTOLUENE	.006
Well 4-8	17 Feb	SAMPLE 1554	5 - VP	Nitrobenzene	< .0001
Well 4-8	17 Feb	SAMPLE 1554	5 - VP	HMX	.0196
Well 4-8	17 Feb	SAMPLE 1554	5 - VP	RDX	.001
Well 4-8	17 Feb	SAMPLE 1554	5 - VP	TNB	.0012
Well 4-8	17 Feb	SAMPLE 1554	5 - VP	DNB	< .0001
Well 4-8	17 Feb	SAMPLE 1554	5 - VP	TETRYL	.0006
Well 4-8	17 Feb	SAMPLE 1554	5 - VP	TNT	.0103
Well 4-8	17 Feb	SAMPLE 1554	5 - VP	2,4-DNT	.003
Well 4-8	17 Feb	SAMPLE 1554	5 - VP	2,6-DNT	< .0001
Well 4-8	17 Feb	SAMPLE 1554	5 - VP	2-AMINO-4,6-DINITROTOLUENE	.0092
Well 4-8	17 Feb	SAMPLE 1554	5 - VP	4-AMINO-2,6-DINITROTOLUENE	.0049
Well 4-8	18 Feb	SAMPLE 800	122 - A	Nitrobenzene	< .0001
Well 4-8	18 Feb	SAMPLE 800	122 - A	HMX	.108
Well 4-8	18 Feb	SAMPLE 800	122 - A	RDX	.165
Well 4-8	18 Feb	SAMPLE 800	122 - A	TNB	.013
Well 4-8	18 Feb	SAMPLE 800	122 - A	DNB	J 0.0001
Well 4-8	18 Feb	SAMPLE 800	122 - A	TETRYL	.0013
Well 4-8	18 Feb	SAMPLE 800	122 - A	TNT	.174
Well 4-8	18 Feb	SAMPLE 800	122 - A	2,4-DNT	.0162
Well 4-8	18 Feb	SAMPLE 800	122 - A	2,6-DNT	< .0001
Well 4-8	18 Feb	SAMPLE 800	122 - A	2-AMINO-4,6-DINITROTOLUENE	.0101
Well 4-8	18 Feb	SAMPLE 800	122 - A	4-AMINO-2,6-DINITROTOLUENE	.0058
Well 4-8	18 Feb	SAMPLE 815	122 - A	Nitrobenzene	< .0001
Well 4-8	18 Feb	SAMPLE 815	202 - A	HMX	.0308
Well 4-8	18 Feb	SAMPLE 815	202 - A	RDX	.305
Well 4-8	18 Feb	SAMPLE 815	202 - A	TNB	.0026
Well 4-8	18 Feb	SAMPLE 815	202 - A	DNB	< .0001
Well 4-8	18 Feb	SAMPLE 815	202 - A	TETRYL	< .0001
Well 4-8	18 Feb	SAMPLE 815	202 - A	TNT	.0322
Well 4-8	18 Feb	SAMPLE 815	202 - A	2,4-DNT	.0047
Well 4-8	18 Feb	SAMPLE 815	202 - A	2,6-DNT	< .0001
Well 4-8	18 Feb	SAMPLE 815	202 - A	2-AMINO-4,6-DINITROTOLUENE	.0092
Well 4-8	18 Feb	SAMPLE 815	202 - A	4-AMINO-2,6-DINITROTOLUENE	.0049
Well 4-8	18 Feb	SAMPLE 830	280 - A	Nitrobenzene	< .0001
Well 4-8	18 Feb	SAMPLE 830	280 - A	HMX	.0492
Well 4-8	18 Feb	SAMPLE 830	280 - A	RDX	.061
Well 4-8	18 Feb	SAMPLE 830	280 - A	TNB	.005
Well 4-8	18 Feb	SAMPLE 830	280 - A	DNB	< .0001
Well 4-8	18 Feb	SAMPLE 830	280 - A	TETRYL	< .0001
Well 4-8	18 Feb	SAMPLE 830	280 - A	TNT	.063
Well 4-8	18 Feb	SAMPLE 830	280 - A	2,4-DNT	.0074
Well 4-8	18 Feb	SAMPLE 830	280 - A	2,6-DNT	< .0001
Well 4-8	18 Feb	SAMPLE 830	280 - A	2-AMINO-4,6-DINITROTOLUENE	.0096
Well 4-8	18 Feb	SAMPLE 830	280 - A	4-AMINO-2,6-DINITROTOLUENE	.0052
Well 4-9	16 Feb	SAMPLE 1100	156 - B	Nitrobenzene	< .0001
Well 4-9	16 Feb	SAMPLE 1100	156 - B	HMX	.0019
Well 4-9	16 Feb	SAMPLE 1100	156 - B	RDX	2.69
Well 4-9	16 Feb	SAMPLE 1100	156 - B	TNB	.004

WELL No.	SAMPLE DATE 1993	FIELD SAMPLE No.	REPORT SAMPLE No.	ANALYTE	MEASURED VALUE mg/L
Well 4-9	16 Feb	SAMPLE 1100	156 - B	DNB	< .0001
Well 4-9	16 Feb	SAMPLE 1100	156 - B	TETRYL	< .0001
Well 4-9	16 Feb	SAMPLE 1100	156 - B	TNT	J 0.0002
Well 4-9	16 Feb	SAMPLE 1100	156 - B	2,4-DNT	< .0001
Well 4-9	16 Feb	SAMPLE 1100	156 - B	2,6-DNT	< .0001
Well 4-9	16 Feb	SAMPLE 1100	156 - B	2-AMINO-4,6-DINITROTOLUENE	< .0001
Well 4-9	16 Feb	SAMPLE 1100	156 - B	4-AMINO-2,6-DINITROTOLUENE	< .0001
Well 4-9	16 Feb	SAMPLE 1115	241 - B	Nitrobenzene	< .0001
Well 4-9	16 Feb	SAMPLE 1115	241 - B	HMX	.0022
Well 4-9	16 Feb	SAMPLE 1115	241 - B	RDX	2.39
Well 4-9	16 Feb	SAMPLE 1115	241 - B	TNB	.0031
Well 4-9	16 Feb	SAMPLE 1115	241 - B	DNB	< .0001
Well 4-9	16 Feb	SAMPLE 1115	241 - B	TETRYL	J 0.0002
Well 4-9	16 Feb	SAMPLE 1115	241 - B	TNT	J 0.0002
Well 4-9	16 Feb	SAMPLE 1115	241 - B	2,4-DNT	< .0001
Well 4-9	16 Feb	SAMPLE 1115	241 - B	2,6-DNT	< .0001
Well 4-9	16 Feb	SAMPLE 1115	241 - B	2-AMINO-4,6-DINITROTOLUENE	< .0001
Well 4-9	16 Feb	SAMPLE 1115	241 - B	4-AMINO-2,6-DINITROTOLUENE	< .0001
Well 4-9	16 Feb	SAMPLE 1130	330 - B	Nitrobenzene	< .0001
Well 4-9	16 Feb	SAMPLE 1130	330 - B	HMX	.002
Well 4-9	16 Feb	SAMPLE 1130	330 - B	RDX	2.38
Well 4-9	16 Feb	SAMPLE 1130	330 - B	TNB	.0036
Well 4-9	16 Feb	SAMPLE 1130	330 - B	DNB	< .0001
Well 4-9	16 Feb	SAMPLE 1130	330 - B	TETRYL	< .0001
Well 4-9	16 Feb	SAMPLE 1130	330 - B	TNT	< .0001
Well 4-9	16 Feb	SAMPLE 1130	330 - B	2,4-DNT	< .0001
Well 4-9	16 Feb	SAMPLE 1130	330 - B	2,6-DNT	< .0001
Well 4-9	16 Feb	SAMPLE 1130	330 - B	2-AMINO-4,6-DINITROTOLUENE	< .0001
Well 4-9	16 Feb	SAMPLE 1130	330 - B	4-AMINO-2,6-DINITROTOLUENE	< .0001
Well 4-9	16 Feb	SAMPLE 1455	0 - VP **	Nitrobenzene	< .0001
Well 4-9	16 Feb	SAMPLE 1455	0 - VP **	HMX	.0023
Well 4-9	16 Feb	SAMPLE 1455	0 - VP **	RDX	2.51
Well 4-9	16 Feb	SAMPLE 1455	0 - VP **	TNB	.0047
Well 4-9	16 Feb	SAMPLE 1455	0 - VP **	DNB	< .0001
Well 4-9	16 Feb	SAMPLE 1455	0 - VP **	TETRYL	< .0001
Well 4-9	16 Feb	SAMPLE 1455	0 - VP **	TNT	< .0001
Well 4-9	16 Feb	SAMPLE 1455	0 - VP **	2,4-DNT	< .0001
Well 4-9	16 Feb	SAMPLE 1455	0 - VP **	2,6-DNT	< .0001
Well 4-9	16 Feb	SAMPLE 1455	0 - VP **	2-AMINO-4,6-DINITROTOLUENE	< .0001
Well 4-9	16 Feb	SAMPLE 1455	0 - VP **	4-AMINO-2,6-DINITROTOLUENE	< .0001
Well 4-9	17 Feb	SAMPLE 0810	0 - VP	Nitrobenzene	< .0001
Well 4-9	17 Feb	SAMPLE 0810	0 - VP	HMX	.0018
Well 4-9	17 Feb	SAMPLE 0810	0 - VP	RDX	2.12
Well 4-9	17 Feb	SAMPLE 0810	0 - VP	TNB	.0032
Well 4-9	17 Feb	SAMPLE 0810	0 - VP	DNB	< .0001
Well 4-9	17 Feb	SAMPLE 0810	0 - VP	TETRYL	< .0001
Well 4-9	17 Feb	SAMPLE 0810	0 - VP	TNT	.0011
Well 4-9	17 Feb	SAMPLE 0810	0 - VP	2,4-DNT	< .0001
Well 4-9	17 Feb	SAMPLE 0810	0 - VP	2,6-DNT	< .0001
Well 4-9	17 Feb	SAMPLE 0810	0 - VP	2-AMINO-4,6-DINITROTOLUENE	< .0001
Well 4-9	17 Feb	SAMPLE 0810	0 - VP	4-AMINO-2,6-DINITROTOLUENE	< .0001
Well 4-9	17 Feb	SAMPLE 0820	0.25 - VP	Nitrobenzene	< .0001
Well 4-9	17 Feb	SAMPLE 0820	0.25 - VP	HMX	.0014
Well 4-9	17 Feb	SAMPLE 0820	0.25 - VP	RDX	1.72
Well 4-9	17 Feb	SAMPLE 0820	0.25 - VP	TNB	.003
Well 4-9	17 Feb	SAMPLE 0820	0.25 - VP	DNB	< .0001
Well 4-9	17 Feb	SAMPLE 0820	0.25 - VP	TETRYL	< .0001
Well 4-9	17 Feb	SAMPLE 0820	0.25 - VP	TNT	< .0001
Well 4-9	17 Feb	SAMPLE 0820	0.25 - VP	2,4-DNT	< .0001
Well 4-9	17 Feb	SAMPLE 0820	0.25 - VP	2,6-DNT	< .0001
Well 4-9	17 Feb	SAMPLE 0820	0.25 - VP	2-AMINO-4,6-DINITROTOLUENE	< .0001
Well 4-9	17 Feb	SAMPLE 0820	0.25 - VP	4-AMINO-2,6-DINITROTOLUENE	< .0001
Well 4-9	17 Feb	SAMPLE 0830	0.50 - VP	Nitrobenzene	< .0001
Well 4-9	17 Feb	SAMPLE 0830	0.50 - VP	HMX	.0006

WELL No.	SAMPLE DATE 1993	FIELD SAMPLE No.	REPORT SAMPLE No.	ANALYTE	MEASURED VALUE mg/L
Well 4-9	17 Feb	SAMPLE 0830	0.50 - VP	RDX	1.72
Well 4-9	17 Feb	SAMPLE 0830	0.50 - VP	TNB	.001
Well 4-9	17 Feb	SAMPLE 0830	0.50 - VP	DNB	< .0001
Well 4-9	17 Feb	SAMPLE 0830	0.50 - VP	TETRYL	< .0001
Well 4-9	17 Feb	SAMPLE 0830	0.50 - VP	TNT	< .0001
Well 4-9	17 Feb	SAMPLE 0830	0.50 - VP	2,4-DNT	< .0001
Well 4-9	17 Feb	SAMPLE 0830	0.50 - VP	2,6-DNT	< .0001
Well 4-9	17 Feb	SAMPLE 0830	0.50 - VP	2-AMINO-4,6-DINITROTOLUENE	< .0001
Well 4-9	17 Feb	SAMPLE 0830	0.50 - VP	4-AMINO-2,6-DINITROTOLUENE	< .0001
Well 4-9	17 Feb	SAMPLE 0840	0.75 - VP	Nitrobenzene	< .0001
Well 4-9	17 Feb	SAMPLE 0840	0.75 - VP	HMX	< .0001
Well 4-9	17 Feb	SAMPLE 0840	0.75 - VP	RDX	.361
Well 4-9	17 Feb	SAMPLE 0840	0.75 - VP	TNB	.0005
Well 4-9	17 Feb	SAMPLE 0840	0.75 - VP	DNB	< .0001
Well 4-9	17 Feb	SAMPLE 0840	0.75 - VP	TETRYL	< .0001
Well 4-9	17 Feb	SAMPLE 0840	0.75 - VP	TNT	< .0001
Well 4-9	17 Feb	SAMPLE 0840	0.75 - VP	2,4-DNT	< .0001
Well 4-9	17 Feb	SAMPLE 0840	0.75 - VP	2,6-DNT	< .0001
Well 4-9	17 Feb	SAMPLE 0840	0.75 - VP	2-AMINO-4,6-DINITROTOLUENE	< .0001
Well 4-9	17 Feb	SAMPLE 0840	0.75 - VP	4-AMINO-2,6-DINITROTOLUENE	< .0001
Well 4-9	17 Feb	SAMPLE 0850	1 - VP	Nitrobenzene	< .0001
Well 4-9	17 Feb	SAMPLE 0850	1 - VP	HMX	< .0001
Well 4-9	17 Feb	SAMPLE 0850	1 - VP	RDX	.0817
Well 4-9	17 Feb	SAMPLE 0850	1 - VP	TNB	< .0001
Well 4-9	17 Feb	SAMPLE 0850	1 - VP	DNB	< .0001
Well 4-9	17 Feb	SAMPLE 0850	1 - VP	TETRYL	< .0001
Well 4-9	17 Feb	SAMPLE 0850	1 - VP	TNT	< .0001
Well 4-9	17 Feb	SAMPLE 0850	1 - VP	2,4-DNT	< .0001
Well 4-9	17 Feb	SAMPLE 0850	1 - VP	2,6-DNT	< .0001
Well 4-9	17 Feb	SAMPLE 0850	1 - VP	2-AMINO-4,6-DINITROTOLUENE	< .0001
Well 4-9	17 Feb	SAMPLE 0850	1 - VP	4-AMINO-2,6-DINITROTOLUENE	< .0001
Well 4-9	17 Feb	SAMPLE 0930	2 - VP	Nitrobenzene	< .0001
Well 4-9	17 Feb	SAMPLE 0930	2 - VP	HMX	< .0001
Well 4-9	17 Feb	SAMPLE 0930	2 - VP	RDX	.0051
Well 4-9	17 Feb	SAMPLE 0930	2 - VP	TNB	< .0001
Well 4-9	17 Feb	SAMPLE 0930	2 - VP	DNB	< .0001
Well 4-9	17 Feb	SAMPLE 0930	2 - VP	TETRYL	< .0001
Well 4-9	17 Feb	SAMPLE 0930	2 - VP	TNT	< .0001
Well 4-9	17 Feb	SAMPLE 0930	2 - VP	2,4-DNT	< .0001
Well 4-9	17 Feb	SAMPLE 0930	2 - VP	2,6-DNT	< .0001
Well 4-9	17 Feb	SAMPLE 0930	2 - VP	2-AMINO-4,6-DINITROTOLUENE	< .0001
Well 4-9	17 Feb	SAMPLE 0930	2 - VP	4-AMINO-2,6-DINITROTOLUENE	< .0001
Well 4-9	17 Feb	SAMPLE 1010	3 - VP	Nitrobenzene	< .0001
Well 4-9	17 Feb	SAMPLE 1010	3 - VP	HMX	< .0001
Well 4-9	17 Feb	SAMPLE 1010	3 - VP	RDX	.004
Well 4-9	17 Feb	SAMPLE 1010	3 - VP	TNB	< .0001
Well 4-9	17 Feb	SAMPLE 1010	3 - VP	DNB	< .0001
Well 4-9	17 Feb	SAMPLE 1010	3 - VP	TETRYL	< .0001
Well 4-9	17 Feb	SAMPLE 1010	3 - VP	TNT	< .0001
Well 4-9	17 Feb	SAMPLE 1010	3 - VP	2,4-DNT	< .0001
Well 4-9	17 Feb	SAMPLE 1010	3 - VP	2,6-DNT	< .0001
Well 4-9	17 Feb	SAMPLE 1010	3 - VP	2-AMINO-4,6-DINITROTOLUENE	< .0001
Well 4-9	17 Feb	SAMPLE 1010	3 - VP	4-AMINO-2,6-DINITROTOLUENE	< .0001
Well 4-9	17 Feb	SAMPLE 1050	4 - VP	Nitrobenzene	< .0001
Well 4-9	17 Feb	SAMPLE 1050	4 - VP	HMX	< .0001
Well 4-9	17 Feb	SAMPLE 1050	4 - VP	RDX	.005
Well 4-9	17 Feb	SAMPLE 1050	4 - VP	TNB	< .0001
Well 4-9	17 Feb	SAMPLE 1050	4 - VP	DNB	< .0001
Well 4-9	17 Feb	SAMPLE 1050	4 - VP	TETRYL	< .0001
Well 4-9	17 Feb	SAMPLE 1050	4 - VP	TNT	< .0001
Well 4-9	17 Feb	SAMPLE 1050	4 - VP	2,4-DNT	< .0001
Well 4-9	17 Feb	SAMPLE 1050	4 - VP	2,6-DNT	< .0001
Well 4-9	17 Feb	SAMPLE 1050	4 - VP	2-AMINO-4,6-DINITROTOLUENE	< .0001
Well 4-9	17 Feb	SAMPLE 1050	4 - VP	4-AMINO-2,6-DINITROTOLUENE	< .0001

WELL No.	SAMPLE DATE 1993	FIELD SAMPLE No.	REPORT SAMPLE No.	ANALYTE	MEASURED VALUE mg/L
Well 4-9	18 Feb	SAMPLE 700	156 - A	Nitrobenzene	< .0001
Well 4-9	18 Feb	SAMPLE 700	156 - A	HMX	.0005
Well 4-9	18 Feb	SAMPLE 700	156 - A	RDX	.434
Well 4-9	18 Feb	SAMPLE 700	156 - A	TNB	< .0001
Well 4-9	18 Feb	SAMPLE 700	156 - A	DNB	< .0001
Well 4-9	18 Feb	SAMPLE 700	156 - A	TETRYL	< .0001
Well 4-9	18 Feb	SAMPLE 700	156 - A	TNT	< .0001
Well 4-9	18 Feb	SAMPLE 700	156 - A	2,4-DNT	< .0001
Well 4-9	18 Feb	SAMPLE 700	156 - A	2,6-DNT	< .0001
Well 4-9	18 Feb	SAMPLE 700	156 - A	2-AMINO-4,6-DINITROTOLUENE	< .0001
Well 4-9	18 Feb	SAMPLE 700	156 - A	4-AMINO-2,6-DINITROTOLUENE	< .0001
Well 4-9	18 Feb	SAMPLE 715	241 - A	Nitrobenzene	< .0001
Well 4-9	18 Feb	SAMPLE 715	241 - A	HMX	< .0001
Well 4-9	18 Feb	SAMPLE 715	241 - A	RDX	.0778
Well 4-9	18 Feb	SAMPLE 715	241 - A	TNB	< .0001
Well 4-9	18 Feb	SAMPLE 715	241 - A	DNB	< .0001
Well 4-9	18 Feb	SAMPLE 715	241 - A	TETRYL	< .0001
Well 4-9	18 Feb	SAMPLE 715	241 - A	TNT	< .0001
Well 4-9	18 Feb	SAMPLE 715	241 - A	2,4-DNT	< .0001
Well 4-9	18 Feb	SAMPLE 715	241 - A	2,6-DNT	< .0001
Well 4-9	18 Feb	SAMPLE 715	241 - A	2-AMINO-4,6-DINITROTOLUENE	< .0001
Well 4-9	18 Feb	SAMPLE 715	241 - A	4-AMINO-2,6-DINITROTOLUENE	< .0001
Well 4-9	18 Feb	SAMPLE 730	330 - A	Nitrobenzene	< .0001
Well 4-9	18 Feb	SAMPLE 730	330 - A	HMX	< .0001
Well 4-9	18 Feb	SAMPLE 730	330 - A	RDX	.0154
Well 4-9	18 Feb	SAMPLE 730	330 - A	TNB	< .0001
Well 4-9	18 Feb	SAMPLE 730	330 - A	DNB	< .0001
Well 4-9	18 Feb	SAMPLE 730	330 - A	TETRYL	< .0001
Well 4-9	18 Feb	SAMPLE 730	330 - A	TNT	< .0001
Well 4-9	18 Feb	SAMPLE 730	330 - A	2,4-DNT	< .0001
Well 4-9	18 Feb	SAMPLE 730	330 - A	2,6-DNT	< .0001
Well 4-9	18 Feb	SAMPLE 730	330 - A	2-AMINO-4,6-DINITROTOLUENE	< .0001
Well 4-9	18 Feb	SAMPLE 730	330 - A	4-AMINO-2,6-DINITROTOLUENE	< .0001
Well 4-8	17 Feb	BAILOR RINSEATE	B2	Nitrobenzene	< .0001
Well 4-8	17 Feb	BAILOR RINSEATE	B2	HMX	< .0001
Well 4-8	17 Feb	BAILOR RINSEATE	B2	RDX	< .0001
Well 4-8	17 Feb	BAILOR RINSEATE	B2	TNB	< .0001
Well 4-8	17 Feb	BAILOR RINSEATE	B2	DNB	< .0001
Well 4-8	17 Feb	BAILOR RINSEATE	B2	TETRYL	< .0001
Well 4-8	17 Feb	BAILOR RINSEATE	B2	TNT	< .0001
Well 4-8	17 Feb	BAILOR RINSEATE	B2	2,4-DNT	< .0001
Well 4-8	17 Feb	BAILOR RINSEATE	B2	2,6-DNT	< .0001
Well 4-8	17 Feb	BAILOR RINSEATE	B2	2-AMINO-4,6-DINITROTOLUENE	< .0001
Well 4-8	17 Feb	BAILOR RINSEATE	B2	4-AMINO-2,6-DINITROTOLUENE	< .0001
Well 4-9	16 Feb	BAILOR RINSEATE	B1	Nitrobenzene	< .0001
Well 4-9	16 Feb	BAILOR RINSEATE	B1	HMX	< .0001
Well 4-9	16 Feb	BAILOR RINSEATE	B1	RDX	< .0001
Well 4-9	16 Feb	BAILOR RINSEATE	B1	TNB	< .0001
Well 4-9	16 Feb	BAILOR RINSEATE	B1	DNB	< .0001
Well 4-9	16 Feb	BAILOR RINSEATE	B1	TETRYL	< .0001
Well 4-9	16 Feb	BAILOR RINSEATE	B1	TNT	< .0001
Well 4-9	16 Feb	BAILOR RINSEATE	B1	2,4-DNT	< .0001
Well 4-9	16 Feb	BAILOR RINSEATE	B1	2,6-DNT	< .0001
Well 4-9	16 Feb	BAILOR RINSEATE	B1	2-AMINO-4,6-DINITROTOLUENE	< .0001
Well 4-9	16 Feb	BAILOR RINSEATE	B1	4-AMINO-2,6-DINITROTOLUENE	< .0001
Well 4-9	17 Feb	PUMP RINSEATE	P1	Nitrobenzene	< .0001
Well 4-9	17 Feb	PUMP RINSEATE	P1	HMX	< .0001
Well 4-9	17 Feb	PUMP RINSEATE	P1	RDX	< .0001
Well 4-9	17 Feb	PUMP RINSEATE	P1	TNB	< .0001
Well 4-9	17 Feb	PUMP RINSEATE	P1	DNB	< .0001
Well 4-9	17 Feb	PUMP RINSEATE	P1	TETRYL	< .0001
Well 4-9	17 Feb	PUMP RINSEATE	P1	TNT	< .0001
Well 4-9	17 Feb	PUMP RINSEATE	P1	2,4-DNT	< .0001
Well 4-9	17 Feb	PUMP RINSEATE	P1	2,6-DNT	< .0001

WELL No.	SAMPLE DATE 1993	FIELD SAMPLE No.	REPORT SAMPLE No.	ANALYTE	MEASURED VALUE mg/L
Well 4-9	17 Feb	PUMP RINSEATE	P1	2-AMINO-4,6-DINITROTOLUENE	< .0001
Well 4-9	17 Feb	PUMP RINSEATE	P1	4-AMINO-2,6-DINITROTOLUENE	< .0001
METHOD BLANK				Nitrobenzene	< .0001
METHOD BLANK				HMX	< .0001
METHOD BLANK				RDX	< .0001
METHOD BLANK				TNB	< .0001
METHOD BLANK				DNB	< .0001
METHOD BLANK				TETRYL	< .0001
METHOD BLANK				TNT	< .0001
METHOD BLANK				2,4-DNT	< .0001
METHOD BLANK				2,6-DNT	< .0001
METHOD BLANK				2-AMINO-4,6-DINITROTOLUENE	< .0001
METHOD BLANK				4-AMINO-2,6-DINITROTOLUENE	< .0001

< Less than detection limit

** Sample 1455 from well 4-9 was a 0 purge volume sample taken on 16 February. Due to problems with the submersible pump after the sample was taken, sampling was stopped for the day. Another 0 purge volume sample was taken when the well was sampled on 17 February

J Estimated value

REPORT DOCUMENTATION PAGE

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Charlie B. Whitten, Jerald D. Broughton

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13. ABSTRACT *(Maximum 200 words)*

Analysis of the chemical explosives data from up to six sampling events for wells 4-8 and 4-9 at Umatilla Army Depot, OR, show the concentration of explosives in each well have varied several orders of magnitude. Sampling crews had noted the purge water in well 4-8 changed color after the first well volume was removed. A field sampling prgram was conducted to collect samples from each well as the wells were purged. Point source bailer samples were taken at the top, middle, and bottom of the water column in each well before and after each well was purged. The point source bailer samples showed the explosive analytes concentrations decreased from the top to the bottom of the water columns with the pre-purge samples being up to an order of magnitude higher than the post-purge samples. The explosive analytes concentrations in the purge water dropped one to two orders of magnitude or below detection limit after one well volume was removed. The chemical data indicate that the explosive contaminants are leaking into the wells through the well casing at or near the top of the water column in each well.

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